GENDER, POLITICS, AND RADIOACTIVITY RESEARCH IN VIENNA, 1910-1938

by

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ABSTRACT

What could it mean to be a physicist specialized in radioactivity in the early 20th century Vienna? More specifically, what could it mean to be a woman experimenter in radioactivity during that time? This dissertation focuses on the lived experiences of the women experimenters of the *Institut für Radiumforschung* in Vienna between 1910 and 1938. As one of three leading European Institutes specializing in radioactivity, the Institute had a very strong staff. At a time when there were few women in physics, one third of the Institute's researchers were women. Furthermore, they were not just technicians but were independent researchers who published at about the same rate as their male colleagues. This study accounts for the exceptional constellation of factors that contributed to the unique position of women in Vienna as active experimenters.

Three main threads structure this study. One is the role of the civic culture of Vienna and the spatial arrangements specific to the *Mediziner-Viertel* in establishing the context of the intellectual work of the physicists. A second concerns the ways the Institute's architecture helped to define the scientific activity in its laboratories and to establish the gendered identities of the physicists it housed. The third examines how the social conditions of the Institute influenced the deployment of instrumentation and experimental procedures especially during the Cambridge-Vienna controversy of the 1920s. These threads are unified by their relation to the changing political context during the three contrasting periods in which the story unfolds: a) from the end of the 19th century to the end of the First World War, when new movements, including feminism, Social Democracy, and Christian Socialism, shaped the Viennese political scene, b) the period of Red Vienna, 1919 to 1934, when Social Democrats had control of the City of Vienna, and c) the period from 1934 to the *Anschluss* in 1938, during which fascists and Nazis seized power in Austria. As I show, the careers of the Institute's women were

shaped in good part by the shifting meanings, and the politics, that attached to being a "woman experimenter" in Vienna from 1910 to the beginning of the Second World War.

To my parents, Katina and Theodoros Rentetzis

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I begun this study as an attempt to answer a puzzling question: why were there so many women working in radioactivity research in Vienna from 1910 to 1938? Based on canonical stories about women's secondary roles in science, and particularly in physics, the number of women at the Institute for Radium Research in Vienna during the first part of the 20th century seemed interestingly exceptional. Moreover, the fact that those women worked as experimenters and not as laboratory support staff or technicians attracted my attention. For being able to transform the initial question into what came to be the main theme of this work, I owe my acknowledgments first and foremost to my advisor Richard Burian. Dick's guidance has been essential in more than one sense. I have constantly taken great advantage of his time and willingness to read anything I might write. While English is not my native language, Dick had to deal not only with the content of my work but with its grammar as well. At the cost of his own time and research I have learned how to formulate my ideas, pay attention to arguments, and to try to put together a number of different perspectives in a coherent way. Tough enough to push me hard and at the same time sensitive enough to know how far I can go, Dick followed each of my steps very closely and gave me the freedom to pursue my interests. By doing so he was the first to face my frustrations, my impatience, my anxieties but, I hope, also my excitement.

Bernice Hausman introduced me to gender theory and pointed out to me the theoretical potential of my work much clearer than I was able to do it. Gary Downey graced me with more than suggesting sources and ways to conceptualize my topic. He stood by me in extremely difficult personal times, more than I have ever expected. To Joe Pitt I owe not only an acknowledgment for playing an essential role in the whole dissertation process, but an apology as well. I lost some important time and the chance to learn from him. I admit, Joe, that I am stubborn. To Peter Galison I am grateful for inspiring and encouraging this study and for his insightful and decisive suggestions in all the crucial turning points of the dissertation process.

There is one debt that never seems to get repaid, but constantly increases. To Aristides Baltas I owe more than acknowledging the key role he played in my studies. I

met Aristides at the graduate program in History and Philosophy of Science, at the National Technical University of Athens in Greece. He had and still has a unique ability to listen to and a remarkable generosity in helping students find their way, not only through scholarly ideas and dissertation projects but also through life. One of the first to establish the HPS program in Greece, Aristides nurtured almost all of us Greeks who pursued studies in the field. He opened up the program to international scholars and worked on several projects, embracing his students and welcoming others who were interested in HPS studies. I dared to imagine that I could leave Greece and study in the United States because I had Aristides' encouragement and support. I became self-confident through our long discussions that took up more than my fair share of his time. I am sure, Aristidi that the exchange has not been mutual and I am grateful for your patience.

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Throughout my studies in the United States I had the unconditional support of Peter Machamer. Peter, a philosopher of science at the HPS department of the University of Pittsburgh, became a regular and welcome visitor in Athens thanks to Aristides' efforts to bring our program in the forefront of scholarly discussions in the field. I was fortunate to meet Peter during the time I was considering to apply to North American Universities. Besides providing information on possible programs in the United States to apply to and shaping application proposals, Peter functioned as the link between two of my self images: who I already was and who I was becoming. Knowing Greeks and Greece well

and at the same time an American himself, Peter had predicted my cultural shock and was there to help every single minute I asked for. Soon Barbara Machamer joined what I considered my family in this country and she generously made me feel that I joined hers. Thanks to them and Aristides, I also taxed the patience and generosity of George Gale, Ted McGuire, and Jim Bogen as well.

My work on the history of the Institute for Radium Research and the lived experiences of the women that it hosted has not been just *part of my life*. Rather, it *has been my life* for the last six years. A number of Greek friends have patiently listened to my stories and encouraged my adventures. Besides Giorgos and Lara I would like to warmly thank Spiros Petrounakos, Dimitris Papagianakos, Giorgos Malamis, Kostas Pagondiotis, Gianna Katsiaboura, Maria Rafailidou, Evi Stathopoulou, Panos Theodorou, Vasilis Raisis, Fotini Vasiliou, Margio Chaidopoulou, Petros Damianos, Maria Pournari, Aris Aragiorgis, and Georgia Arnelou. In the United States there have been a few people whose support has been indispensable. My dear friend Brad Kelley, with whom I disagree on almost everything, made me part of his family and his life. His generosity went so far that he read every single sentence of this dissertation, trying to fix my rough English. Ty Brady has been the one who, during the last years, makes sure that occasionally I get out of my "cave," patiently listens to my complains, and cares for me. Expert in designing maps, Ty generously spent his free time and drew the map of the *Mediziner-Viertel* that I include here. Sarah Mitchell, John, Nathan and Owen Cotton, Joan Marie, Pei Koay, Voula Saridakis, Jean Miller, Ann Fitzpatrick, Jody Roberts, Anne McNabb, and Glenn Bugh, each contributed their unique part in making this experience valuable to me. To thank Tyler Smith is a difficult task. Besides offering to me emotional support she went through the whole dissertation draft suggesting changes and using her experience to carefully advise me on the dissertation process. She and Michael Fowler make me feel confident that the end is in site.

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Without the resources available at Virginia Tech, the assistantships awarded to me, the enormous support of the librarians and archivists working at the Interlibrary Loan division of the Virginia Tech library, and the help of the stuff of my department, especially that of Debbie Law, Karin Snider, and Terry Zapata this work could be impossible to be completed. I owe my special thanks to the directors of my department, first Gary Downey and then Valerie Hardcastle, for facilitating my stay in the United States, as well as Ruth Athansson and Monika Gibson for easing my life as an international student.

Besides Virginia Tech, there is one institution to which I owe the most not only for providing the financial support for pursuing research but also for making available an astounding network of STS researchers and dear friends. The year 2000 I received a fellowship from the Institute for Advanced Studies on Science Technology and Society, in Graz, Austria. There I had the opportunity to do research and, most important, to become part of an amazing group of people from all over the world. Ines Ohme, Harald Rohraher, Dimitri Efremenko, Sieghard Lettner, Christine Wächter, Günter Getzinger, Radostina Anguelova, Annette Ohme-Reinicke, Gerald Berger, and Alan Marshal made my time in Graz not only creative but enjoyable as well. I am grateful especially to Doris Wallnöfer, Ulrich Dolata, Ellen Balka, and Bernhard Wieser for sharing several beers at *Raumberg* and endless discussions about our work and lives. Bernhard, as you once said, the reasons we choose the dissertation topics we do are deeper than just a scholarly excuse. It is because of who we are and what we deeply are concerned about. Thanks for making this obvious to me.

Substantial parts of chapter 4 came out of my discussions with Spiros Flevaris, an architect who taught me the difficult task of reading architectural plans, instilled to me his passion about architecture, and, luckily for me, changed my life in several respects. To thank him here is probably not enough and not appropriate.

There is one person that I do not know how to thank than by being who I became during the years of my stay in the United States. Jane Keppel-Benson followed this process closely, she triggered it, and I hope she enjoyed it as well. To my sister I owe a passionate, difficult, but unique relationship. Last, those who are silently missing from this narrative are my parents. How can I really thank those who deprived themselves in order that my sister and I could find our ways in life? In front of such an enormous debt I can only remain silent and devote this dissertation to them.

Maria Rentetzi

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INTRODUCTION

In 1910 a Viennese lawyer and industrialist combined resources with the Austrian Academy of Sciences and the state to establish the *Institut für Radiumforschung*—Institute for Radium Research—in Vienna. The Institute specialized in investigating the chemical and physical aspects of radioactivity and was devoted exclusively to research. The physicist Franz Exner, prominent member of the Viennese bourgeoisie and the Austrian Academy of Sciences, became its formal director. His student, Stefan Meyer, a young and promising physicist, handled not only the supervision and planning of the Institute but also its administration from the beginning. This study is framed around the history of Vienna's Radium Institute and it is guided by a main question: what could it mean to be a physicist and particularly a woman experimenter, specializing in radioactivity, during the early 20th century Vienna? The story unfolds during three politically contrasting periods: a) from the end of the 19th century to the end of the First World War, when new political forces such as feminists, Social Democrats, and Christian Socials marked Austria's political scene, b) from 1919 to 1934, the period known as Red Vienna, when Social Democrats had control of the City of Vienna and c) the period from 1934 to the *Anschluss* in 1938, during which fascists and Nazis seized power in Austria. The aim is to get to the shifting meanings of the "woman experimenter" in Vienna from the Institute's establishment to the beginning of the Second World War.

The Viennese physicists, having at their disposal the rich resources of uranium pitchblende of the St. Joachimstal mines in Bohemia, first entered the small network of radioactivity researchers as merchants and main providers of radium. But was this all that a Viennese physicist was? Shortly after, by establishing the Institute for Radium Research, the Viennese physicists proved to be prominent experimenters and became leading figures in the European community of radioactivity research. Serious competitors were located in only three other research centers: the Curie's Institute in Paris, Ernest Rutherford's laboratory in Manchester, and the Laboratorium Hahn-Meitner at the Kaiser Wilhelm Institute for Chemistry in Berlin. During the 1910s the investigations carried out at the Vienna Institute involved many physicists, including a surprising number of women. But what exactly did it mean to be a physicist, and particularly a woman physicist, specializing in radioactivity, in Vienna at this time?

Working in a fairly new discipline, physicists were negotiating their identities at the boundary between physics and chemistry, while they were also entering into the world of medicine and biology. How did the interdisciplinarity of the field play into the formation of women's identities as experimental physicists? What gender relations made it possible, in the first place, for women to enter into the Institute and radioactivity research?

By the end of the First World War the political situation posed new challenges to the Institute for Radium Research. While Vienna was recovering from the war, the Institute faced severe financial problems, the loss of its main radium resource—that of the St. Joachimstal mines—and, the reorganization of its personnel. The Institute's preeminence in radioactivity was at stake, as was the prestige of the Viennese physicists who had lost the secure feeling of belonging to an empire. The fragmented economy of the new Austrian republic created a sense of deep instability. In 1919 the Social Democratic Party gained control of the city of Vienna, which it retained for the following fifteen years. A socialist program of municipal reforms was soon designed to transform the social, cultural, educational, and economic infrastructure of the capital. It also redefined meanings of sexual difference shared by the Viennese society and the ways relations of power were constructed based on those meanings. The discourse of the Social Democrats significantly changed the understanding of gender and the politics around it as well. Research at the Institute took shape not only in the midst of political reforms but also within the context of disciplinary changes.

Rutherford had just moved from Manchester to the Cavendish Laboratory in Cambridge and was offered generous material resources to organize his research. Unchallenged, he embarked on studying the phenomena of artificial disintegration, the transmutation of one element to another by bombardment of alpha particles and the emission of long-range particles. Rutherford's group, mainly young male students of physics, tied their research to the reliability of the scintillation counter, an instrument deployed for counting tiny flashes of light produced on a zinc sulfide screen by the impact of charged particles. It was Hans Pettersson, a Swedish physicist, and his group in Vienna who presented the most serious challenge to the reliability of the techniques, the accuracy of theories and experimental results, and most importantly Rutherford's credibility in the field.

Pettersson arrived in Vienna in 1922. With the support of Swedish patrons and the International Education Board, he reshaped the material culture of the Radium

Institute and introduced the Viennese physicists to research on artificial disintegration. By doing so he also offered them the opportunity to regain their prestige by seriously competing with the best research laboratory of their time. Not surprisingly, Pettersson's work attracted a new generation of physicists at the Institute. In contrast to the British group, one third of the Viennese experimenters were women. The controversy that was generated between the Vienna and Cambridge groups was heated, involving competitive publications in the most prestigious physics journals of the time. Without doubt, thanks to the controversy, the Vienna Institute was boosted to the forefront of research on a field that was already shifting from radioactivity to nuclear physics.

How was the meaning of being a physicist affected during this period in the setting of the Radium Institute? The men and women of Pettersson's group collaborated closely to challenge the authority of Rutherford's laboratory and to bring their Institute to the cutting-edge of research. What did it mean, then, particularly for the women of the group, to work in one of the top research centers in radioactivity, competing with an established authority such as the Cavendish laboratory? What were the factors that contributed to their exceptional participation in Pettersson's scientific team? How did they succeed in forming their identities as experimental physicists instead of technicians and members of the Institute's support staff?

In the early 1930s it became clear that the discipline was in flux. Those who were destined to survive in the world of nuclear physics were not the Viennese. While certain experimental techniques failed to be reliable and new skills and methods were required in the laboratory, the Viennese physicists insisted in saving their experimental culture. The resolution of the controversy in favor of the British group, the entry of several other research groups into the field, and the difficult political circumstances in Austria led to disarray in the Vienna Institute. From 1934 to 1938, first the Fascists and then the Nazis seized power in the country. During these years political and racial persecutions constantly reminded the physicists of the Institute that the new regimes did not tolerate Social Democrats and Jews, most particularly if they were women. What could it mean, then, to be a woman physicist in Vienna when research on radioactivity by all accounts declined badly?

After the *Anschluss* in 1938 Jewish men and women of the Institute were forced to withdraw from their positions at the Institute and flee Austria. How did some of the women cope with the destruction of their professional identities? During the Second World War the passage of the center of physics from Europe to the United States had an enormous impact not only on the personal lives of the European scientists in exile but on physics as well. How did the women of the Vienna Institute adapt to the changes in the patterns of laboratory work, the politics of collaboration, and the culture of their new scientific community after 1938? What kind of personal choices did the women who remained at the Institute make? What was the spectrum of their political beliefs?

This study is partly an exploration of women's professional identities as experimental physicists in Vienna from 1910 to 1938. The history of their professionalization goes hand in hand with the history of radioactivity as a discipline. What could it mean to be a woman experimenter conducting first rate research on radioactivity and nuclear physics in a metropolitan city such as Vienna? In the time span of this study, neither the meaning of "woman" nor that of "experimental physicist," specializing in radioactivity, remained fixed and stable. As the careers of the physicists studies in this dissertation show, both categories depended on political and scientific changes that shaped the Radium Institute in the early 20th century Vienna.

To understand the historicity of the notion of "woman," the fact that what it meant to be a woman in Vienna was not stable and monolithic, I focus on the open-ended, constantly ongoing interaction between individual women working at the Radium Institute and their world. To do this, I employ the notion of "lived experience," which designates the whole of a person's subjectivity.[1] Marietta Blau, Elisabeth Rona, Berta Karlik, Elisabeth Kara-Michailova, and Hertha Wambacher were some of the women, among many others, who made sense of their situations and actions in the early 20th century Vienna and in physics through their lived experiences. At the same time the women's set of practices in the laboratory and in their everyday lives sedimented over time and integrated at what came to be their lived experiences. The decisions that the women made of how to interact with their world cannot explained or reduced simply to gender, race or any other of their situations. Rather, it was this complex, co-produced process of being in various situations, such as gender, race, class, and nationality, that constantly constructed their subjectivity and defined who they were as women.

[1] Moi, *What is a Woman?* (1999), pp. 56, 63.

The world that these women faced had not been stable either. The discourse developed by the feminists of the *fin-de-siècle* Vienna challenged traditional beliefs about women's proper sphere of action. Thanks to feminist activists and their persistent petitions, upper class Viennese women gained access to university education and opportunities for professional careers in the sciences. Exner and Meyer, with their distinct collegial ethos, welcomed a number of them in the Institute for Radium Research and in a promising new discipline. By the end of the First World War, although women had already been integrated into the physics community, significant changes in the number of those working in radioactivity coincided with the social democratic reforms of the 1920s and Pettersson's arrival in the Institute. The discourse of the Social Democratic Party gave a strong political meaning to what a woman should be. Although the socialist ideology provided the framework for women from all social strata to envision themselves as active members of the Viennese society, those who were able to pursue academic studies were still the ones from the affluent classes. Last, the political discourse of the authoritarian regimes that ruled the country, beginning in 1934, and led to the *Anschluss* in 1938, played a key role in destroying the democratic cultural and social policies of the Red Vienna together with the meanings that it had created.

While dramatic changes in political ideologies reinforced different lived experiences for the women in Vienna, what it meant to be an experimental physicist working in radioactivity was also transformed over time. In this study I explore the ways these transformations were manifested in and shaped by the urban setting of the Institute for Radium Research in the area known as the *Mediziner-Viertel*. To connect the urban construction of the city with the context of scientific activity is to pay attention to the physicality and locality of networks of scientific institutions in the city. In the case of Vienna, the *Mediziner-Viertel* was a surprisingly dense network of academic institutions and medical facilities, developed on the margins of *Ringstrasse* and extending behind the University.

The Radium Institute, located in the heart of the *Viertel*, was enmeshed, socially and intellectually, in the life of the city. The spatial proximity of multidisciplinary research and teaching centers and the Germanic tradition of providing lodging to directors, assistants, and their families within the institutes, strengthened the scientific community and promoted interdisciplinary crossings. Scientific changes involving experimental techniques, instruments, expertise, personnel, and teaching faculty as well as cultural, political, and interdisciplinary discussions took place in the coffeehouses of the *Mediziner-Viertel* and in the laboratories of the scattered institutes. What could it mean to be an experimental physicist working in radioactivity in such an interdisciplinary context? How were the disciplinary boundaries symbolically manifested through spatial segregation? What kind of scientific boundary work reflects the fact that the Radium Institute was deliberately built between the Physics and the Chemistry Institutes and in the neighborhood of one of Vienna's most important hospitals? How did this locality and the face-to-face interaction of the Viennese radioactivity community affect the entry of women into the Institute as experimental physicists? The history of the lived experiences of the women working on radioactivity is necessarily part of Vienna's civic history and its urban reconstruction. It is a history linked to the ways buildings of scientific institutes were arranged and to the matrix of interdisciplinary exchanges those arrangements reinforced. The Viennese physicists, although cosmopolitan in their interests, were closely attached to localities. Within the context of this inclusive culture in the *Mediziner-Viertel,* women and men physicists discussed the leading scientific publications of the day, interacted with physicians and chemists, and traded instruments and radium preparations.

Another way to portray the changes of what it meant to be an experimental physicist and particularly how women, working in the field, embodied these meanings, is to emphasize the transformations of the material culture of the Institute. Technologies such as x-ray photographic films, scintillation counters, and photographic plates of emulsions, all tabletop, portable, and cheap apparatuses easy to design and use were closely tied to the experimenters' everyday lives. Thus, the instruments tell us the stories of their designers and users. For instance, the transfer of the scintillation counter from the laboratory benches of Rutherford's group to the Vienna Institute is about politics of collaboration between the physicists in each group, gender assumptions concerning the instrument's use, and strategies of retaining authority in the field. In each setting, definitions of experimental tasks as skilled and unskilled were constructed based on different gender relations. While Pettersson's group valued team work and favored women's presence, the British group that revolved around Rutherford included no women.

To illustrate the different gender structures in the two laboratories, the ways the scintillation counter was used by the two groups, and the negotiations that took place during the Vienna-Cambridge controversy is to focus on the sociology of the controversy. Emphasizing the laboratory as a system of labor and a space of social activity, one can get to the meaning of being a woman experimental physicist in the particular Viennese culture. In the late 1920s the Viennese shifted parts of the apparatus from one laboratory bench to another in order to save a technique that by all accounts was dying. Instead the group at the Cavendish laboratory was introducing the novel methods of wave mechanics to nuclear problems, altering their instrumentation and theoretical approaches. While the loyalty of the Viennese experimentalists to their material culture says something about their insecurity in the field, changes in Rutherford's group point to the importance of funding and resources in scientific practice. In the end, for the Viennese to lose their epistemic authority was less important than to lose funding and be "gently" excluded from the scientific community through the private resolution of the controversy. Thus, sociological attention is centered on how the controversy was resolved, on how women responded to the rearrangements of their laboratory, and what kind of boundary work evolved out of their actions. To tell the history of technology transfer, nonetheless, and to focus on scintillation counters and zinc sulfide screens is also to explore the epistemology of the experiment. For instance, by sustaining the material culture of their Institute, the women who conducted experiments on artificial disintegration in Vienna in the 1920s, were also maintaining the gender assumptions of their group of who had the right to perform those experiments and design the instruments. After the *Anschluss* some of the Institute's women were forced to become part of large scientific groups where access to the instruments was hierarchically controlled. What did it mean for such important women physicists such as Blau, Rona, or Kara-Michailova to lose control over their experiments, abandon their patterns of research, and alter their work relations in the laboratory? How did this affect their experimental work? Part of the answer turns on the shift from scintillation screens to photographic plates, photoelectric cells, and finally photomultipliers in the 1940s.

To understand the shifting meaning of the "woman experimenter" working at the Radium Institute over three decades, in chapter 1 I position this study in the context of the relevant literature. Challenging the use of gender in history of science, I introduce the concept of lived experience as a way to capture the complexity of what it meant to be a woman and, especially a woman experimenter, in Vienna during the period of this study. In chapter 2 I set the cultural and scientific scene within which the Institute was placed. I emphasize the ways in which the experimental practices in radioactivity were institutionalized through the establishment of the Institute. At the end of the 19th century the *Mediziner-Viertel* was created in accordance with a well-thought out political plan to serve the needs of the Viennese scientific community. The locality of the Institute in the *Viertel* as a distinct building devoted to radium research stated that radioactivity, although a branch of physics, was an emerging discipline. Thus physicists working in the field identified with their profession in a new way; they were now recognized as specialists. To reify their identities, they standardized radium measurements and created a forum for printed disciplinary discussions. The first volume of the *Mitteilungen,* the annual bulletin of the Institute, came out during the Institute's very first year. Having already partially altered their status in Viennese society, through feminist politics, upper class women were welcomed into the new discipline.

Although radioactivity was being formed as a new discipline, it clearly stood on the border between physics and chemistry. In chapter 3 I discuss the central role of radium as a "boundary object" in the emerging of radioactivity as a "trading zone."[2] The scientists who were brought together had a wide range of backgrounds, including physics, chemistry, medicine, geology, and biology. I argue that the decision to establish the Radium Institute was made in order to stabilize and strengthen interdisciplinary exchanges by giving status to the Viennese physicists. Focusing on women, I explore how the inderdisciplinarity of the field eased their entrance to the Institute during its first decade. Women like Blau formulated their professional identities in a way that gave them the flexibility to move from physics and medical institutions to industries, transferring at the same time back and forth their knowledge on instruments and experimental methods.

In chapter 4 I follow the physicists' attempt to organize their research in one of the most technologically advanced institutes of their time. Interested in the ways that the laboratory spaces were gendered, I examine the interior of the building and use photographs, architectural plans, and sketches as historical witnesses of what it meant to be a woman working in the Institute. I often break away from the chronological narrative in order to bring in evidence from letters and descriptions written in later years. I argue that architecture mattered for women's work in radioactivity in two ways. On the one hand, it reflected the gender assumptions of its designers, including the directors of the Institute. On the other hand, it constructed the space in such a way that women were able to obtain their own workbenches and work rooms as well as to have access to the laboratory machinery. Paraphrasing Virginia Woolf, the women at the Institute certainly had "a lab of their own."

Chapter 5 brings us to the period of Red Vienna, when Social Democrats gained control of the city after World War I. From 1919 to 1934 they fostered radical programs of social, educational, and welfare reforms using the city as laboratory for their cultural and political experiments. Moreover, the Social Democratic Party implemented a specific discourse on gender using mass media, architecture, and the party's ideological apparatus to promote it. I explore the impact of the social democratic politics on what it meant to be a woman working in a scientific setting. Within this context I approach Meyer not only as a kind and welcoming mentor but also as a political figure. In cooperation with the city's socialist leaders, he offered to his personnel an astonishing network of medical institutions where physicists such as Blau, Rona, and Hilda Fonovits found jobs over time. In this chapter I also trace the gender politics of collaboration and employment in the Institute's publications, financial revenues, and expenses. The argument is that the social democratic politics played a major role in enabling women to participate so extensively in the work of the Radium Institute during Red Vienna. The party's discourse provided the framework for a unique political culture, which, for the most part, allowed women to interact with the world without being reduced to their gender or race.

In chapters 6 and 7 I follow the course of the controversy between the Viennese and the British. Breaking with the canonical story, which treats the losing sites as unimportant, I emphasize the role of the Viennese physicists in this scientific dispute. I am concerned with the transformation of instruments and experimental techniques and the meanings those embodied about the role of gender in the experimental practice. How did women's lived experiences play into their attempts to save certain techniques? In 1927 James Chadwick, Rutherford's collaborator, visited Vienna in order to resolve the discrepancies in experimental results between the two groups. For one day he assumed control of the laboratory and replicated crucial experiments in the absence of Pettersson. Demonstrating that the Viennese physicists

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[2] On the notion of "boundary object" see Star and Griesemer, "Institutional Ecology" (1989), pp. 387-

had been performing unreliable experiments, Chadwick left Vienna having agreed to a private resolution of the controversy. In contrast to stereotypical narratives of this incident, I argue that women of the Viennese group played a significant role in designing experiments, constructing instruments, and formulating theories. Instead of attributing to women the secondary role of laboratory support staff, I focus on their scientific research and ask what it meant for them to work as experimental physicists in this first rate Institute. Additionally, I argue that the loss of financial support mattered in women's decisions to remain and work in radioactivity in that it drove their decision to cross over to oceanography.

The last chapter brings us to the end of the story by focusing on the abrupt decline of the *Mediziner-Viertel* after the political upheavals and the fascist seizure of power in 1933. Here I examine the degree to which the new political and social order affected the researchers of the Institute. How did patterns of life and politics of collaboration change after 1933? With an emphasis on those women who played an important role at the Institute I follow their trajectories from 1933 to 1938. After the *Anschluss* Jewish men and women were forced into exile, underlining the fact that gender and racial discrimination were closely intertwined.

Instead of an epilogue I sketch the story of Blau's eventful immigration to the United States and her struggle to survive in the new world of high energy physics. This particular history provides some hints about how and why women shifted from being active researchers in the cultural and political environment of Red Vienna to becoming merely technicians and support stuff performing secondary tasks in the physics laboratories of the 1940s and 1950s.

A Note on Sources

Historians are expected to rely on archives as the primary depositories of facts and decisive historical sources. As historian of science Helge Kragh defines it, "a source is an objectively given, material item from the past, created by human beings."[3] Going through a list, not an exhaustive one but with the most important sources, Kragh includes letters, notebooks, manuscripts, scientific papers, and diaries.

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420. On the notion of "trading zone" see Galison, *Image and Logic* (1997).

[3] Kragh, *Introduction to Historiography of Science,* (1987), p. 120.

In my study I went through published scientific papers, photographs, letters, notebooks of finances and revenues, manuscripts, the annual bulletin of the Institute for Radium Research as well as the almanac of the Austrian Academy of Sciences. Trips to several archives scattered throughout Europe, some in the United States and even in Mexico, gave me the opportunity to follow the trajectories of some of the protagonists of this story and reconstruct their lived experiences. Oral history and interviews filled some of the gaps about which the archival material was silent. Despite the fact that these common historical sources are absolutely necessary, they are not sufficient to grasp the complexity of the lived experiences of the women who worked in the Vienna Institute. Photographs reconstruct space, relations, hierarchies, and the material culture of the discipline, but are usually silent about boundary exchange in science. Here I looked at photographs not just as illustrations of a historical period but also, as evidence of the politics of collaboration within the Institute. Moreover, while traditional histories of women in science have paid great attention to archival materials, they have overlooked the discursive evidence provided by architecture. In the case of the Radium Institute architecture is a valuable source for historical analysis, for it expresses, contains, and portrays gender discourse. The historian who is willing to pose questions of how gender politics and specific meanings of human relations define and are defined by spatial divisions and arrangements can find some answers in the inner architecture of the laboratory and its spatial positioning in the city. I argue that the ways scientific buildings are arranged, interconnected, designed, and function defines the ways practitioners alter, diversify, and rework the patchwork structure of physics. To answer the question of what could it mean to be a physicist and particularly a woman physicist working on radioactivity in the specific setting of Vienna, I pay attention to the architecture of the buildings that hosted their research and to the urban structure of the city that nurtured them.

CHAPTER 1
GENDER AND LIVED EXPERIENCES

In 1999 Joan Scott, a historian who had shaped recent historiography by providing a sophisticated analysis and use of the concept of gender, admitted that she found herself using ‘gender’ less and less in her work.[1] “Many feminist scholars who use the term ‘gender’ do so while explicitly rejecting the premise that ‘men’ and ‘women’ are historically variable categories. This had had the effect of denying ‘gender’ its radical academic and political agency. It is, these days, a term that has lost its critical edge.”[2] In a similar vein, in *Has Feminism Changed Science?* (1999) Londa Schiebinger emphatically argues that “Feminism has brought some remarkable changes to science.” Nevertheless, “the fashionability of the term ‘gender,’” as she admits, “resulted in its expropriation.”[3] The term is often misused by being equated to women or sex.

In the late 1970s feminist scholars fostered diverse and rapidly expanding projects that sought ways to criticize science and academia from a gender perspective. Equated to the concept of women or not, the concept of gender functioned as a political apparatus within academia as it was deployed to critique many dimensions of science and scientific practice. Paying attention either to the fact that women were underrepresented in the sciences or to the gendered nature of science, prominent historians and philosophers of science positioned themselves as critics of certain discriminatory academic politics. Yet, they reached further, challenging the objectivity and authority of science as well as its documented history. Besides providing a critical discourse, they also shaped a new scholarship on gender and science and legitimized research on ignored scholarly areas. If this critical edge of the concept of gender is lost, as Scott and Schiebinger point out, then one asks the obvious question: how can we still discuss the relation of gender to science in a meaningful and critical way?

In what follows I trace the development of scholarship on “women in science” and “gender and science,” two intertwined pieces of the same puzzle. The first theme emerged when social and political circumstances that affected academia, especially in

[1] Scott, *Gender and the Politics of History*, (1999), p. xii.
[2] Scott, *Gender and the Politics of History*, (1999), p. xii.
[3] Schiebinger, *Has Feminism Changed Science?,* (1999), p. 16.

North America, prompted historians of science and technology to investigate the role of "women in science." During the last three decades of scholarly work on this theme three different historiographical patterns were formed; a) women's biographies, b) women's education, and c) women's scientific networks and collaborations. Each of them aimed to highlight mechanisms that excluded women from the sciences and to document their accomplishments despite the discriminations and difficulties they faced.

The second theme, "gender and science," emerged through the development of what is known as feminist theory. A conceptual shift from the term "sex" to that of "gender" aimed to indicate the social construction of sexual difference. Historians shifted their interest from the discourse of exclusion and marginalization to that of the social construction of sexual difference in science and traced gender metaphors mainly in medicine and biology in order to undermine the neutrality of science. Finally, poststructuralist theorists attempted to show that sex is as constructed as gender and that it is a historical and social phenomenon, not an essential feature.

The passage from "women in science" to "gender and science" marks a shift in the historiography of feminist studies and indicates a transformation in epistemology and theories of gender. The two themes have a parallel development and often are entangled in such a way that gender is about women. The linguistic swing between "women in science" and "gender and science" is more than a careless slippage or a variety in phrasing, for it reflects the bewilderment caused by thinking about gender in terms of social norms and sex in terms of nature. In 1999 Toril Moi addressed the sex/gender distinction in *What is a Woman?,* arguing against the constructivist understanding of women as gender. Taking into account Moi's philosophical discussion of the concept of women, I rethink the issue of gender and science. At one level this chapter serves as a periodization of the main historiographical streams concerning women, gender, and science. At the same time drawing on the specific historical and cultural setting of early to mid-20th century Vienna, I attempt to offer a way of capturing the complexity of gendered scientific practices by introducing the term of lived experiences.

1.1. Women in Science

In the early 1970s a political feminist agenda that aimed to highlight the mechanisms that excluded women from the sciences and to document their accomplishments despite all the discriminations and difficulties they faced, prompted a historical investigation of women's participation in sciences.[4] Three different historiographical patterns emerged out of historians' acknowledgment that women have always been in a situation different than that of men, a situation socially and culturally constructed and often with fewer degrees of freedom than had by men.

The first concern for historians studying women in science was to make visible the significant number of women who were ignored or mistreated by conventional histories of science. Although they always faced difficulties, women were not excluded from science without serious challenge. Those who somehow managed to enter into the sciences through a process of everyday conflicts and negotiations, had to be documented. Individual cases of women who were neglected, in spite of the fact that their work was as important as or more important than that of their male colleagues, were meticulously added to the lists of famous scientists. A number of detailed biographies, biographical dictionaries, and collective volumes on women scientists appeared in the literature, documenting the unfairness, brutality, and male-dominating ideologies that were found in all scientific disciplines.[5] Studying exceptional women in various scientific fields, historians were forced by their own findings to reconsider a few self-evident assumptions. Questions such as what is considered as science, what counts as scientific, and who has the right to practice science, how, and where, marked historical research in the late 1970s and 1980s.

The second historiographical pattern that emerged, concerned the educational and employment opportunities women missed and the structure of the scientific institutes that formally or informally excluded them.[6] As women, especially before the end of the 19th century, were not allowed to practice science in its main and recognized institutions, the historiographical interest shifted from the main

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4 See Kohlstedt, "Women in the History of Science," (1995), pp. 39-58.

5 For the case of physics see for example: Herzenberg and Howes, *Their Day in the Sun,* (1999); Pflaum, *Grand Obsession: Madame Curie and her World,* (1989); Pycior, "Reaping the Benefits," (1993), pp. 301-23; Pycior, "Marie Curie's 'Anti-Natural Path,'" (1987), pp. 191-215; Rayner-Canham, M. and Rayner-Canham G., *Harriet Brooks*, (1992); Sime, *Lise Meitner,* (1996).

universities to the "entering wedges," the colleges where women sought careers in sciences.[7] Women chose indirect paths to enter the sciences by either creating their own colleges and clubs or depending on male family members to secure position in laboratories. A look at the patterns of women's participation in scientific research highlighted the decisive roles of their fathers, brothers, husbands, and, to an extent, even male mentors.

Margaret Rossiter's outstanding work, *Women Scientists in America* (1982), transformed the historiography of women in science. She was the first to tackle systematically issues such as employment, educational patterns, and the types of recognition accorded or, more recently, withheld from women. Rossiter meticulously gathered an incredible amount of data and archival material that demonstrated in a quantitative way what historians and feminist scholars had been arguing for anecdotally, by focusing on individual cases. Women enjoyed little or no recognition for their scientific contributions and vehemently struggled to carve out a place for themselves in science. The most fascinating part of Rossiter's work is the amount of information she gathered from college records, fellowship awards, and industrial employment of women scientists, setting the ground for comparative and case studies. At the same time she launched a whole new branch of scholarship by viewing women in terms of the labor economics of the world of modern American science.

The third historiographical pattern discussed women's networks, research schools, and mentor chains. The assumption behind the effort to uncover women's networks and collaborations was to highlight their strength and solidarity in the male-dominated world of science. Feminist scholars utilized their political agendas and historical interests to emphasize the effectiveness of women's collaborations in changing the practice of their sciences. Historians attempted to document, reveal, and legitimate women's significance and active role in scientific practice.[8]

Along with their studies of newly discovered exceptional women, feminist scholars uncovered not only mechanisms of exclusion, patterns of discrimination, and social constraints for those women who sought scientific careers but also thousands of

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[6] Within the second historiographical trend and for the case of physics see for example Kidwell, "Cecilia Payne-Gaposchkin," (1987), pp. 216-238; Ogilvie, "Marital Collaboration," (1987), pp. 104-128.

[7] This is a term that Rossiter uses to highlight the role of women's colleges in securing a position in science for women in North America (Rossiter, *Women Scientists in America*, (1984), p. 27.)

[8] A representative book within the third historiographical trend focused on physics is Rayner-Canham, M. and Rayner-Canham, G. *A Devotion to Their Science*, (1997).

archival pages and historical sources, documented oral histories, and women's memoirs. The first generation of historians who studied women in science not only legitimated women's existence and contributions but also created a new field of knowledge. They attracted the attention of their peers, collaborated generously with students and colleagues, and opened up pathways for further research. Financial support of their work and the professionalization of this new subdiscipline in history of science came as a natural consequence. Women scientists emerged as historical subjects and their experiences, retrieved through archival sources, acquired great importance. This same fact, nonetheless, had the double and contradictory effect of isolating women in science as a separate and special topic of history of science. The very same process by which women recovered their past ended up treating them as a historical supplement. "Women in science" became a special theme within history of science, highlighting the importance of the topic but at the same time circumscribing its study largely to women historians interested in feminist scholarship.

1.2. The "Sex Role" Theoretical Apparatus

Woven into a new historiography of science the three patterns, a) women's biographies, b) women's education, and c) women's networks and collaborations, articulated a new discourse in history of science, that of sex roles. I argue that feminist historians, drawing heavily on social theory, adopted the concept of "role" to account for women in science.[9] According to this theory, a set of actions or behaviors is socially assigned to men and women, constraining their personal expectations and collective interactions. As sociologist R. Connell argues, "being a man or a woman means enacting a general role definitive of one's sex—the 'sex role'."[10] Stereotypical interpersonal expectations are made effective through social structures and mechanisms of punishment and reward. Girls, for example, are typically praised for being patient and obedient, boys for being active and assertive. Agencies of socialization such as family, school, media, and social institutions are responsible for teaching roles and creating role models. Finally, the embodiment of a role, male or female, constrains individual desires. The deviation from an expected role is considered as a failure in socialization.

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[9] For the concept of "role" in social theory see Connell, *Gender and Power,* (1987), pp. 47-54.
[10] Connell, *Gender and Power*, (1987) p. 48.

In putting the 'sex role' theoretical apparatus to work and asserting firmly the historical presence of women in science, I argue that historians also put forward a stereotypical image of women. They established a distinct historical discourse of exclusion, emphasizing the force of expected roles in shaping individual lives. Especially for the case of women in physics, I maintain that certain readings of archival documents and historical sources guided by the 'sex role' theoretical apparatus created mainly two portraits for women physicists. The first presents women as exceptional individuals who, like Maria Curie, made extraordinary discoveries and scientific contributions by their heroic struggle against all obstacles. They were the curiosities who succeeded in becoming known within their scientific community and, often, the broader public. Nonetheless, they never managed to fit into the traditional picture of women of their time. Deviating from the norm, they became role models for all the other women who sought careers in physics. Thus, it is not surprising that the disproportionate number of women in radioactivity research in the 1920s and 1930s is often explained by reference to Marie Curie as the model of their personal choices to follow careers in science. Yet, in 1911 the French press brutally disparaged Marie Curie for her affair with her colleague Paul Langevin putting in jeopardy her scientific merit. How, then, could the "sex role" theory account for the fact that young women in the 1910s chose to enter a field in which the leading figure, Marie Curie, although she was awarded two Nobel Prizes, was absolutely vulnerable to the accusations of the press? What was so attractive in adopting as a model a woman who suffered from her own choices to have a career in science?[11]

The second portrait describes a number of women scientists who despite the difficulties and constraints they faced, assisted their male colleagues in a variety of physics subfields, often invisibly. These women were not able to alter the norm as the few did, but they embodied their "female role" as patient and obedient assistants in social institutions previously forbidden to them. In the absence of alternatives they were ready to accept strenuous and difficult work conditions and enter unpromising fields, frequently those already abandoned by pioneering men. Presupposing that scientific fields are rigid areas with well-defined and stable boundaries, the metaphor of "getting in and out" of a discipline fails to account for dynamic interdisciplinary exchanges and disciplinary transformations. On the contrary, the boundaries of

[11] On Marie Curie's unfortunate adventures during that period see Pycior, "Marie Curie," (1997), pp. 31-50.

scientific disciplines are in constant negotiations, shaped by the work done on the crossroads of several intersecting fields.[12]

I argue that these two portraits of women in physics have framed the historical perspective of feminist historians of science to such a degree that they highlighted a specific group of guiding questions in their narratives while obscuring a variety of others. The application of 'sex role' theory in history of physics and in science in general, can be described as a form of social determinism that subtracts agency from individuals. Within that theoretical framework, power can only be seen as a top-down mechanism that constrains individuals and traps them in stereotypes. The "sex role" theoretical apparatus led historians to investigate science as a social institution that produces, reinforces, and imposes role models on its practitioners, especially women, through mechanisms of exclusion, segregation, and economic discrimination.

1.3. The Model of Sexual Segregation

In "Sexual Segregation in the Sciences: Some Data and a Model" (1978) based on statistical data of both men's and women's participation in various scientific fields in North America from 1920 to 1938, Rossiter proposes a model of women's careers in science. Rossiter's main reference was Henry Menard's book, *Science: Growth and Change* (1971), where he argued that the "growth rate" of a science has a significant effect on the careers of scientists in the field, since professional recognition and advancement comes earlier in a fast-growing field of knowledge. Taking this into account, Rossiter determines the growth rate for various fields in reference to women and extends it not only to their careers but primarily to their employment opportunities. The conclusion is that:

> Women were not only likely to enter and be welcomed into rapidly growing fields but they were, at the same time, more willing than men to endure the hardships of a stagnant or shrinking field. They were relatively less attracted to fields undergoing average growth, where normal competitive and discriminatory practices prevailed.[13]

As Rossiter argues, physics is one of the fields that confirms her hypothesis. According to data drawn from the *American Men of Science*, in 1920 twenty-one women were working in physics and in 1938 their number had increased to sixty-

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[12] On boundary work in science see for example Gieryn, *Cultural Boundaries of Science*, (1999).
[13] Rossiter, "Sexual Segregation in the Sciences," (1978), p. 147.

three. Their rate of increase, according to Rossietr, is simply estimated to be 200%. Since women are typically paid less than men, the immediate inference is that it is easier to be accepted in rapidly growing fields that lack highly qualified people. Playing with numbers available in Rossiter's table, I reproduce here the part that concerns physics (see table 1.1).[14]

Table 1.1 Men and Women in Physics in North America, 1920-1938

	1920		**1938**		**rate of increase**
	actual no.	**%**	**actual no.**	**%**	**%**
Women	21	2.4	63	3.4	200
Men	864	97.6	1825	96.6	111.2

If one shifts the focus on men, then one sees that their rate of increase in the field is 111.2%, a lot lower than that for women, although the actual numbers of men working in physics for both years are incomparably larger than that of women. The data shows that men seem to enter the field much more slowly than women. Notice also that despite the fact that women's actual number in the field tripled from 1920 to 1938, the percentage in the field as compared with men increased just 1%. Taking into account the great number of men entering the field, this is to be expected.

There is a distinct conceptual distance between the statistical data and the explanations that accompany Rossiter's tables. Statistical reports legitimize models of social structures in what seems to be an indubitable way and they obscure questions about the ways we problematize and contextualize the categories in use.[15] For instance, the above numbers are completely silent about women's activities in the discipline. What kind of positions did these women hold and what was the nature of their tasks? Moreover, from the above numbers it is difficult to make any inferences about the willingness of these women to accept difficult positions or the relative rate at which they are paid in comparison to their male colleagues. One cannot infer the shortage of highly qualified people in a field based on the rate of increase. Also, the statistical method in use is not specific about the ways that the growth rate is

[14] Based on table 1: Percentage of Women in the Field in 1938 versus Growth Rates, 1920-38, Rossiter, "Sexual Segregation," (1978) p. 148.

[15] For the use of statistics in history and the politics they involve see Scott, "A Statistical Representation of Work," (1999), pp. 113-138.

measured. In *Women Scientists in America* Rossiter provides valuable insights based on her meticulous research in North America. To produce, however, a "model" applicable to all cases and historical instances is to suggest that gender relations are subject to universal models and categories independent of any historical, cultural, national, and political background. It is significant that almost twenty years later Rossiter, assessing the work of historians who studied women in science, questions the methods that have been used. "We have to begin to take stock of these field and subfield differences more systematically than in the past—the situation is not the same for all women in science or even for those in *one* science."[16]

1.4. The Stereotype of Women as Assistants

Rossiter's model of sexual segregation became normative and was used to support the assumptions of a number of historians who argued that women typically work in physics as tolerant assistants, perform auxiliary tasks, and are willing to accept the passive role of classifying and scanning scientific data.[17] The work of women in radioactivity has been used as an illustrative example.

Although Marelene and Geoffrey Rayner-Canham are willing to "argue more positively" and accept that new fields such as radioactivity offered a kind of excitement to women seeking a career in science, the stereotype of women as patient assistants frames their work. They insist that "research in radioactivity also involved tedious, painstaking, and repetitive work and that this was the reason that men avoided the field while women thrived in it."[18] Adopting Rossiter's explanatory model of sexual segregation in sciences, they present radioactivity as a field analogous to astronomy. The comparison becomes persuasive and leads us back to Rossiter's earlier work. As she argued "in astronomy women entered the field and accepted bleak employment prospects, while men left the field or did not enter it at all."[19] However, the Rayner-Canhams' claim suffers from internal contradiction. If they accept that radioactivity as a new field offered excitement to women it is hard to argue that it consisted of routine, monotonous, and repetitive tasks that drove men away.

[16] Rossiter, "Which Science? Which Women?," (1997), p. 173
[17] See also Reskin, *Sex Segregation in the Workplace: Trends, Explanations, Remedies*, (1984).
[18] Rayner-Canham, M. and Rayner-Canham G., *A Devotion to Their Science*, (1997), p. 18.

Focusing on three different research schools, the Rayner-Canhams attempt to uncover the roles women played in the field and the reasons that those contributions were overlooked. *A Devotion to their Science*, published in 1997, a collection of articles on individual physicists working in the field mainly in England, Austria, and France, maps the area of women's research. Since radioactivity was a new discipline and the criteria of entrance into the research laboratories were not well defined, women were able to proliferate in a variety of research institutes. The Rayner-Canhams adopt and cite an argument used to explain the entrance of women to biochemistry: "This lack of prestige, due to the slowness of academic chemists to recognize the full power and potential of research in the field, offers one explanation for its relative openness to women."[20]

Criticizing the published biographies of Marie Curie, J. L. Davis points out the same stereotypical image. "It is this evaluation of Marie Curie, as the patient, meticulous chemist that tends to predominate in the literature, obscuring her other abilities and talents."[21] Even for the case of the founder of radioactivity what is appraised is Curie's ability to work hard, painstakingly, and patiently as if those are scientific values essential to women. Paula Gould points out the same fact in her work on women's participation in the physical science in the Cavendish Laboratory from 1870 to 1914. "The title of 'assistant' as applied to women frequently disguised the creative and innovative input that they may contribute to a particular project."[22] The politics of collaboration becomes an important issue of focus in Gould's historical analysis. Her attempt is to reconsider and revalue what has been named as "merely" an assistant. Conventional histories of science fail to acknowledge the role of assistants and collaborators by depicting scientific research as the work of a "lone genius."[23] The main historical questions are centered on the protagonists and the pioneers and thus it becomes a thorny task to disentangle the role of women in the development of a scientific project.

Historian Barbara Becker is also among the few who "dispel the myth of the able assistant."[24] She rewrites the story of the astronomer Margaret Huggins, presenting a different interpretation of her collaboration with her husband, William

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19 Rossiter, "Sexual Segregation," (1978), p. 147.
20 Rayner-Canham, M. and Rayner-Canham G., *A Devotion to Their Science*, (1997), p. 232.
21 Davis, "The Research School of Marie Curie," (1995), p. 322.
22 Gould, "Making Space," (1998), p. 25
23 Gould, "Making Space," (1998), p. 25

Huggins at the turn of the 20th century. As Becker argues, Margaret Huggins' work "not only strengthened but also shaped the research agenda of the Tulse Hill Observatory."[25] Conventional accounts of her contributions to collaborative research on astronomical spectroscopy have been influenced by the traditional gender roles according to which women are assistants, supporters, and care givers. An analysis of the couple's notebooks and papers reveal that they did not follow the pattern of the primary and secondary investigator, the researcher and his assistant. Instead they both contributed equally suggesting methodological changes, designing instruments, and interpreting data.

Why then is it the case that women in physics and, in science in general, are usually depicted as assistants? I argue that the 'sex role' theoretical apparatus strongly shape the historians' expectations to trace women's stereotypical roles in the scientific laboratory. As Ruth Howes and Caroline Herzenberg describe, "we expected to find very few women who had been involved in technical aspects of the Manhattan Project, and colleagues' reactions worked to confirm our expectations."[26] The theoretical scene changed drastically, when in the early 1980s feminist scholars introduced the concept of gender into history of science. Although historians continued to work on "women in science," the main historiographical stream endorsed the concept of gender and offered some novel approaches to the history and philosophy of science. Historians emphasized cultural and social differences within scientific communities and undermined universal stereotypes of women in science.

1.5. Gender as Social Construct

The terms gender and science were for the first time coupled together in 1978.[27] Evelyn Fox Keller in an article in *Psychoanalysis and Contemporary Thought* entitled "Gender and Science," explored the association of the notion of masculinity with that of objectivity and consequently with that of science as well, using the concept of gender as her main analytical tool.[28] The dichotomy between sex as a biological category and gender as a cultural or social category had been already

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[24] Becker, "Dispelling the Myth," (1996), p. 98-111.
[25] Becker, "Dispelling the Myth," (1996), p. 99.
[26] Howes and Herzenberg, *Their Day in the Sun,* (1999), p. 2.
[27] Keller, "Gender and Science," (1978), pp. 409-433. See also Keller, "Gender and Science," (1995), pp. 27-8.

developed in the context of feminist theory in the 1960s and early 1970s.[29] Inheriting the distinction, Keller attempted to deploy the concept of gender in a radical critique of science. "In a classic and self-conscious deployment of naming as a form of political action, they (we) redefined *gender*, in contradistinction to sex, to demarcate the social and political, hence variable meanings of *masculinity* and *femininity* from the biological or presumably fixed categories of *male* and *female*."[30] In 1985 Keller published the *Reflections on Gender and Science* arguing for the existence of an equation between 'masculine' and 'objective' as decisive for the development of modern science and the exclusion of women from it.[31]

A year later Sandra Harding published *The Science Question in Feminism.* She set forth a full-fledged feminist epistemological theory, known as the standpoint theory, based on the epistemic privilege of women's experiences.[32] According to Harding, by sharing common experiences women occupy a unique location and standpoint over nature, which they are able to transform into an epistemological tool. Gender is represented as the crossroad of socially constructed sexual differences and the power relationships imposed by these differences.[33] In *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (1990) Helen Longino links the sex/gender distinction to the procedure of evidential reasoning in order to argue that background assumptions are the means by which contextual values and ideology are incorporated into scientific inquiry.[34] Masculine bias can express itself in the content and process of scientific research given that the same state of affairs X can be taken as evidence for conflicting hypotheses. Thus, evidence can be manipulated and objectivity or in other words intersubjectivity, can only be achieved through an inclusive practice, an assemblage of different positions, and critical discourse.

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[28] Keller, "Gender and Science," (1978), pp. 409-433.

[29] For an account of the very first introduction of the concept of gender by psychiatrists and medical personnel working with transexuals see Hausman, *Changing Sex,* (1995).

[30] Keller, "Gender and Science,"(1995), p. 29.

[31] Keller has an exceptional ability to refine and rework her own theoretical assumptions in such a way that she creates new paths and novel approaches in feminist studies of science. Focussing on her publications one can trace the evolution of the field of 'gender and science.' From an essentialist approach to sex in *A Feeling for the Organism,* (1983), she moved to a psychoanalytic explanation of gender in her *Reflection on Gender and Science,* (1985). Later in *The Secrets of Life,* (1992) Keller brought back the issue of gendered metaphors in science, a theme she first addressed in *Reflections*.

[32] Harding, *The Science Question in Feminism,* (1986).

[33] In her "Women's Standpoints on Nature: What Makes Them Possible," (1997) Harding supports feminist standpoint theory by introducing the idea that men and women belong to different cultures, gendered cultures, a belonging which endows them with different standpoints on nature. For a critique of this see Rentetzi, "Feminist Epistemology," (2002), pp. 103-119.

[34] Longino, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry,* (1990).

The above works soon pervaded disciplines such as philosophy of science and epistemology. Based on the assumption that gender is a social construct, Keller, Harding, and Longino, among others, provided a sophisticated methodological analysis of the interplay of gender and science.[35] They opened up the space for a number of fascinating historical works that illustrated gender biases in medicine, biology, and social sciences. Epistemologically, the new focus on gender as a social construct highlighted ways through which gendered assumptions and metaphors played a role in the construction of scientific knowledge.[36] By relating gender to science, feminist scholars underlined the fact that science is sexualized and that different scientific disciplines are categorized as masculine or feminine, with physics and mathematics on the top of the list of sciences suitable to men. They shifted the focus from women's exclusion from science to the gendered nature of scientific knowledge, challenging binary dichotomies such as nature/culture or objective/subjective. Calling attention to the fact that scientific researchers carry their own gendered assumptions, feminist scholars questioned the notion of objectivity. Moreover, through meticulously researched case studies they demonstrated the ways these assumptions are reflected in the knowledge that scientists produce.[37] For example in "The Egg and the Sperm," Emily Martin demonstrates very persuasively how culture shapes the ways biologists describe the natural world and how stereotypes of cultural definitions of male and female define also scientific accounts

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[35] The literature on gender and science is vast. For general surveys of the subject see for example Keller, "Gender and Science,"(1995) pp. 27-38; Keller and Longino (eds), *Feminism and Science*, (1996); Kerr and Faulkner, "On Seeing Broken Specters: Sex and Gender in Twentieth-Century Science," (1997), pp. 43-60; Kohlstedt, "Women in the History of Science," (1995) pp. 39-58; Kohlstedt and Longino (eds), *Women, Gender and Science,* (1997); Löwy, "Gender and Science," (1999), pp. 514-527; Schiebinger, *Has Feminism Changed Science?,* (1999); Wylie, Okruhlik et al., "Philosophical Feminism: A Bibliographical Guide to Critiques of Science," (1990), pp. 2-36.

[36] Harding's and Longino's works are the most influential in feminist epistemology. Collections of essays among such as the ones following, provide an overview of the central topics: Alcoff (ed), *Feminist Epistemologies,* (1993); Antony and Witt (eds), *A Mind of One's Own: Feminist Essays on Reason and Objectivity,* (1993); Code (ed), *What Can She Know? Feminist Theory and the Construction of Knowledge,* (1991); Haack (ed), *Feminist Epistemology: For and Against*, (1994); Lennon and Whithford (eds), *Knowing the Difference: Feminist Perspectives in Epistemology,* (1994). For a more recent collection of essays on feminist philosophy see Narayan and Harding (eds), *Decentering the Center,* (2000).

[37] See for example: Cohn, "Nuclear Language and How we Learned to Pat the Bomb," (1987) pp. 17-24; Fausto-Sterling, *Myths of Gender,* (1985); Long-Hall, "Biology, Sex-Hormones, and Sexism in the 1920's," (1974), pp. 81-96; Longino and Doell, "Body, Bias, and Behavior: A Comparative Analysis of Reasoning in Two Areas of Research," (1983), pp. 206-227; Martin, "The Cultural Construction of Gendered Bodies," (1989), pp. 143-160; Jordanova, *Sexual Visions,* (1989); Schiebinger, *Nature's Body,* (1993).

of reproduction.[38] In "Skeletons in the Closet" Londa Schiebinger skillfully argues that anatomists of the 18th century paid attention to those parts of the body that were politically significant. The first representations of the female skeleton appeared in European science in the context of defining women's social position.[39] Overall, the understanding of gender as a social construct triggered fruitful research in feminist studies of science and questioned not only stereotypical assumptions about sexual difference but about science as well.[40]

1.6. Gender as a Field of Power

To the feminist scholars that analyzed gender as a social construct, the sex/gender distinction was a powerful tool in order to reject biological determinism. To poststructuralist theorists the same distinction looked as another way to reinforce the distinction between nature and culture that feminists tried to undermine.[41] It was precisely this paradox that Donna Haraway addressed in her *Primate Visions* (1989), where she introduced a postructuralist analysis of the concept of gender. As she argues "…these binarisms have been especially *productive* and especially *problematic* for constructions of female and race-marked bodies; it is crucial to see how the binarisms may be deconstructed and may be redeployed."[42] In rewriting the history of the 20th century primatology, Haraway made it clear that what counts as nature and female in the field is culturally and historically specific and modifiable. She attempted to demonstrate the ways that sex is as culturally constructed as gender, and that the social category of gender depends upon "historisizing the categories of sex, flesh, body, biology, and nature."[43]

While Haraway was working towards a deconstruction of the sex/gender distinction through a critique of science, poststructuralist historiography was utterly transformed by the work of historian Joan Scott. Her article "Gender: A Useful

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[38] Martin, "The Egg and the Sperm," (1991), pp. 485-501.
[39] Schiebinger, "Skeletons in the Closet," (1986), pp. 42-82.
[40]There have been a number of theories analyzing the concept of gender as a social construct. Theories of the origins of patriarchy, Marxists approaches of the concept of gender, and psychoanalytic explanation of sexual difference have dominated theoretical discussions in the late 1970s and 1980s. For a detailed analysis and critique of those approaches see Scott, *Gender and the Politics of History*, (1999).
[41] For earlier critiques see for example Bock, "Women's History and Gender History," (1989), pp. 7-30. For a more recent account of theorizing about gender see Moi, *What is a Woman?,* (1999).
[42] Haraway, *Primate Visions*, (1989), p. 12.
[43] Haraway, "Gender for a Marxist Dictionary," (1991), p. 148.

Category of Historical Analysis" became the most important reference for any historical work on gender after the mid-1980s.[44] Scott introduced gender as an analytic category, a form of knowledge about sexual difference, focusing at the same time on interconnected concepts such as power and politics. The first aspect of gender in her account is its function as a constitutive element of social relationships, based on perceived differences between the sexes. These differences are perceived in a social context through four different ways. First, culturally available symbols suggest multiple representations; second, normative concepts eliminate the metaphoric possibilities of the symbols by fixing interpretations of their meanings; third, notions of politics and references to social institutions and organizations play a part in the construction of gender; and fourth, the formation of subjective identities indicates the construction of gender identities.

The second main aspect of gender is its function as a primary way of signifying relations of power, a field within which power is articulated. Scott's work succeeds in highlighting how meanings of gender and power are co-produced. Both categories are historicized.

Post-structuralist theories and thinkers had a great impact on Scott's articulation of gender. Foucault's notions of power and discourse marked her understanding of gender as knowledge about human relations produced by cultures and societies in large epistemic frames that, in turn, have an autonomous history. In this sense using gender as an analytic category focuses on processes rather than on original causes. "Perhaps the most dramatic shift in my own thinking," as Scott recalls, "came through asking questions about how hierarchies such as those of gender are constructed or legitimized."[45] As all meanings that relate to gender are not fixed but rather dynamic and thus connected to politics, the play of force is involved in any social construction of meanings. Politics becomes the process by which experiences and identities, personal and collective, are constructed by plays of power and knowledge.

The poststructuralist understanding of gender as an analytic category has the virtue of connecting issues of power and politics to the historical and social construction of both sex and gender. In Scott's analysis the main concept is that of sexual difference and her attention as a historian is focused on the ways in which

[44] Scott, "Gender: A Useful Category of Historical Analysis," (1986), pp. 1053-75.
[45] Scott, *Gender and the Politics of History*, (1999), p. 4.

meanings are attributed to such differences in specific historical and cultural settings. By calling the process of attribution 'gender,' she neither opposes it to 'sex' nor implies that sex is outside culture and history.[46] Instead, her concern is about the discourses that construct meanings of sexual difference. She goes beyond the ways actors understand their roles and she focuses on collective identities and on the ways institutions construct normative concepts using scientific discourses.[47]

1.7. Gender, Lived Experiences, and Physics

As Kohlstedt and Longino argued in 1997, "the issues of gender are nowhere more completely explored than in the experiences of women in science, often particularly those women whose work and research in biology and related medical settings involve them in questions of sexuality and reproduction."[48] Although scholars of gender and science centered their attention on the biological and medical sciences, physics has been a more difficult domain to trace any gender assumptions and cultural influences. Sharon Traweek's *Beamtimes and Lifetimes: The World of High Energy Physicists* gives a plausible explanation for the scarcity of studies on gender and physics. "In this book women remain marginal as they are in the laboratory" as she argues.[49]Although her main focus is not on gender, Traweek aims to show how work in high energy physics is masculinized and the practice of physics is engendered. Her

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[46] For a detailed analysis of the poststructuralist understanding of the concept of gender see Moi, *What is a Woman?,* (1999), pp. 30-59. Moi severely criticizes the poststructuralist use of gender, especially in Judith Butler's work, for lacking a grasp of the materiality of the body and reducing the human being to sex or gender. Yet, she sees no reason to undermine Scott's notions, which "has long since become normative" (Moi, *What is a Woman?*, (1999), p. 31).

[47] The poststructuralist emphasis on discourse in relation to gender and the parallel development of science studies provoked a number of research projects that focus on discourse analysis, gender, and science. See for example Hausman, *Changing Sex: Transsexualism, Technology and the Idea of Gender*, (1995); Martin, *The Woman in the Body,* (1987); Rapp, "Constructing Amniocentesis: Maternal and Medical Discourse," (1990), pp. 28-42; Additional, emphasis on issues of power and politics of collaborations prompted novel historical research in several scientific fields. See for example, Dyhouse, "Women Students and the London Medical Schools," (1998), pp. 110-32; Gould, "Women and the Culture of University Physics," (1997), 127-49; Richmong, "Women in the Early History of Genetics", (2001), 55-90; Tamboukou, "Of Other Spaces: Women's Colleges at the Turn of the Nineteenth Century in the UK," (2000), 247-63; Thomson, "Physiology, Hygiene and the Entry of Women to the Medical Profession," (2001), pp.105-26. Scott's work directly influenced Ludmilla Jordanova's analysis of the notion of gender in the context of the historiography of science that discussed in her article "Gender and the Historiography of Science," (1993), pp. 469-83. Jordanova adopted Scott's understanding of gender as an analytic category and suggested its use as "an effective heuristic device" in the context of scientific knowledge, presupposing that science is dense with gendered assumptions.

[48] Kohlstedt and Longino, "The Women, Gender, and Science Question," (1997), p. 7.

[49] Traweek, *Beamtimes and Lifetimes*, (1988), p. 16.

comparative study of two high energy physics communities in the United States and Japan indicates that cultural differences are inscribed not only in the ways physicists design their labs and perform their experiments but also in gender relations. Nonetheless, in both cultures of physics the status of women is similar: they are marginal and they were so for the fifteen years during which Traweek visited physics labs. They definitely worked as scanners more than they engage in physics research. During the time of her research at SLAC, as Traweek mentions, nine of the thirteen scanners were women, six of whom were black and one Asian-American.[50] In their struggle for survival and to secure their position within the community of high energy physics, practitioners learn about timing, their discipline's boundaries, networking, and anxiety. Women are almost absent from these procedures that tie masculinization to professionalization in the competitive world of high energy physics. Even the language in use about detectors is genital: "the imagery of the names SPEAR, SLAC and PEP is clear, as is the reference to the 'beam' as 'up' or 'down.'[51]

Instead of adding more women physicists to the long list of women in science, historian Paula Gould examines how women have been written into and out of histories of physics. She offers alternative ways of "writing history which neither overlook nor overestimate the roles of women in science."[52] Her attempt is to take a "less antagonistic stance" and aims to reconstruct the culture of physics at a specific site, that of the late nineteenth-century Cambridge, from a gendered perspective.[53] On the one hand, the Cavendish Laboratory from the 1880s onwards becomes the context where Gould unfolds her narrative. On the other hand, comparisons to other sites of science teaching within Cambridge University give her the opportunity to situate her case study within the broader science culture. The focus is once more on women, those who participated in physics research at the Cavendish Laboratory and are neglected by conventional histories. The guiding question, though, is not why those women were historically neglected. Instead, Gould adopts a different discourse, that of collaboration, and examines a different issue: "how women assimilated themselves, becoming part of a team and not interlopers."[54]

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[50] Traweek, *Beamtimes and Lifetimes*, (1988), p. 28.
[51] Traweek, *Beamtimes and Lifetimes*, (1988), p. 158
[52] Gould, "Making Space," (1998), p. 24.
[53] Gould, "Women and the Culture of University Physics," (1997), pp. 127-49.
[54] Gould, "Women and the Culture of University Physics," (1997), p. 129.

Themes such as partnership, the politics of collaboration, discourse about the appearance of women and their bodily presence, and the general culture of physics permeate her case study. Thus, a new picture of women's participation in the culture of physics arises: not only were they successfully integrated, having crafted a research place for themselves, but they also played an important role, both social and scientific, within this culture. Men neither ridiculed nor ignored them. As Gould points out, "a history of the Cavendish that ignores their presence does not give an accurate representation of its atmosphere."[55] In fact, Gould's case study brings gender issues front and center in the discussion of the history of physics. Her account of women in the Cavendish laboratory provides the basis for theorizing the interplay of gender and physics in one of the most important laboratories in the *fin-de-siècle* Europe.

However, contemporary feminist debates over the meaning of gender and the ways it is currently used in history of physics and in science in general, ask for a reconsideration of the concept. In *What is a Woman?,* Toril Moi argues that Simone de Beauvoir long ago produced a better theory of sexual difference relying on a single word, the French word *sexe*. In a fascinating, dense, and philosophically informed essay, Moi argues against the need for the sex/gender distinction. She attacks the core of gender theory in order to bring back and theoretically reestablish a simple concept, that of 'woman' through the rereading of a path breaking but nevertheless classical and 'outmoded' work.

To overcome the problems that the distinction sex/gender imposes, Moi denies the distinction altogether and turns to Beauvoir's notion of the body as a situation. As she puts it, "We are always in a situation, but the situation is part of us."[56] Although the body is placed within several other situations such as class, race, and nationality, it is not reduced to any of these. The body is not an object but a situation, an ambiguous one, subject to both nature and culture, and it derives its meaning through this ambiguity. According to Moi, Beauvoir does not deny that biology is fundamental and that the body seriously matters to the way one encounters the world. Our physical abilities clearly define the ways we negotiate the world and our lived experiences. Although subject to nature, this does not mean that the body is a destiny. It is not biologically determined, for biology cannot ground human values. Indeed, this is where the human body derives its ambiguity and this is why the sex/gender

[55] Gould, "Women and the Culture of University Physics," (1997), p. 149.
[56] Moi, *What is a Woman?,* (1999), p. 65.

distinction, by referring to the nature/culture distinction, cannot capture this ambiguity. The way women and men experience the world is with their whole body and not with their sexual parts alone. Their *lived experiences,* designating the whole of a person's subjectivity, encompasses experiences of all kinds of situations such as race, class, and nationality. Speaking in singular, a woman is always in the process of making herself what she is. And she is never simply sex or simply gender.

How can the historian of science benefit from Moi's understanding of "woman"? As I have argued here the narratives of women in physics and science in general often have a tendency to collapse in stereotypical images of women working as assistants to their male colleagues and excluded from exciting scientific fields. The model of universal exclusion and segregation is obviously not adequate to all cases and historical contexts. As Scott's work reminds the historian, "gender" is constructed anew in each local circumstance. Based on a given epistemic, cultural, and political framework, gender provides a way of decoding complex relations of power and points to the fact that the categories of "man" and "woman" are not fixed and universal but rather local and in historical flux. Additionally, Moi's reading of Beauvoir suggests the category of "lived experience" as one that is fruitful for understanding the specificity of women's lives. Moi encourages us to retain the category of "woman" over "gender." Since she is open to the idea that discursive constructions contribute to the meaning of being a woman, her notions of "woman" and "lived experience" help us to enliven rather than eradicate Scott's understanding of gender. What I suggest is that Moi offers a way to link up and explain Scott's historiographic challenge to models of exclusion and segregation. In the study that follows, my attempt is to give life to the lived experiences of the women at the Institute for Radium Research in Vienna from 1910 to 1938, paying attention to localities, relations of power, and meanings of sexual difference in the Viennese society.

CHAPTER 2
THE EARLY YEARS OF THE *MEDIZINER-VIERTEL*: AN *IN VIVO* CULTURAL AND EPISTEMIC LABORATORY

When, in 1886, the physicist Ernest Mach asked "how is humanity to progress safely if not even half of it is walking on an enlightened path,"[1] women had not been accepted yet to the University of Vienna. As he argued in his popular scientific lectures, "the level of education and choice of profession for women should in no way be restricted."[2] In the mid-1890s and while the acceptance of women at the University of Vienna was still under discussion, Mach with his colleagues and directors of the first and second Physics Institutes, Victor von Lang and Franz Exner, founded a committee for the support of women's admission to university studies.[3] Surprisingly, leading figures in the Viennese physics, such as Exner, Mach, and Lang, all members of the intelligentsia and bourgeoisie, contributed immensely to creating a friendly environment for the young women of their social strata to craft space for themselves within the field of physics.

Cradled in *fin-de-siècle* Vienna, such physicists as the young Stefan Meyer, Exner's student and later director of the Institute for Radium Research, inherited their cultural meanings about sexual difference and a collegial ethos of working in physics from Vienna's cultural and scientific milieu. At the turn of the century, Vienna was an extraordinary cultural setting where psychoanalysts, architects, artists, writers, musicians, politicians, philosophers, and scientists transformed their fields of knowledge, established new ones, and defined new ways of being. The city's intelligentsia produced distinct "schools" of thought in, architecture, music, painting, philosophy, and psychology. Figures such as the architects Adolf Loos and Otto Wagner, the social critic Karl Kraus, the composers Gustav Mahler and Arnold Schönberg, the painters Gustav Klimt and Egon Schiele, the philosopher and author Robert Musil, and the founder of psychoanalysis Sigmund Freud are only a few of those who marked the turn of the century but they are certainly those whom the names contributed to the myth of Vienna as one of the most creative milieus in Europe.

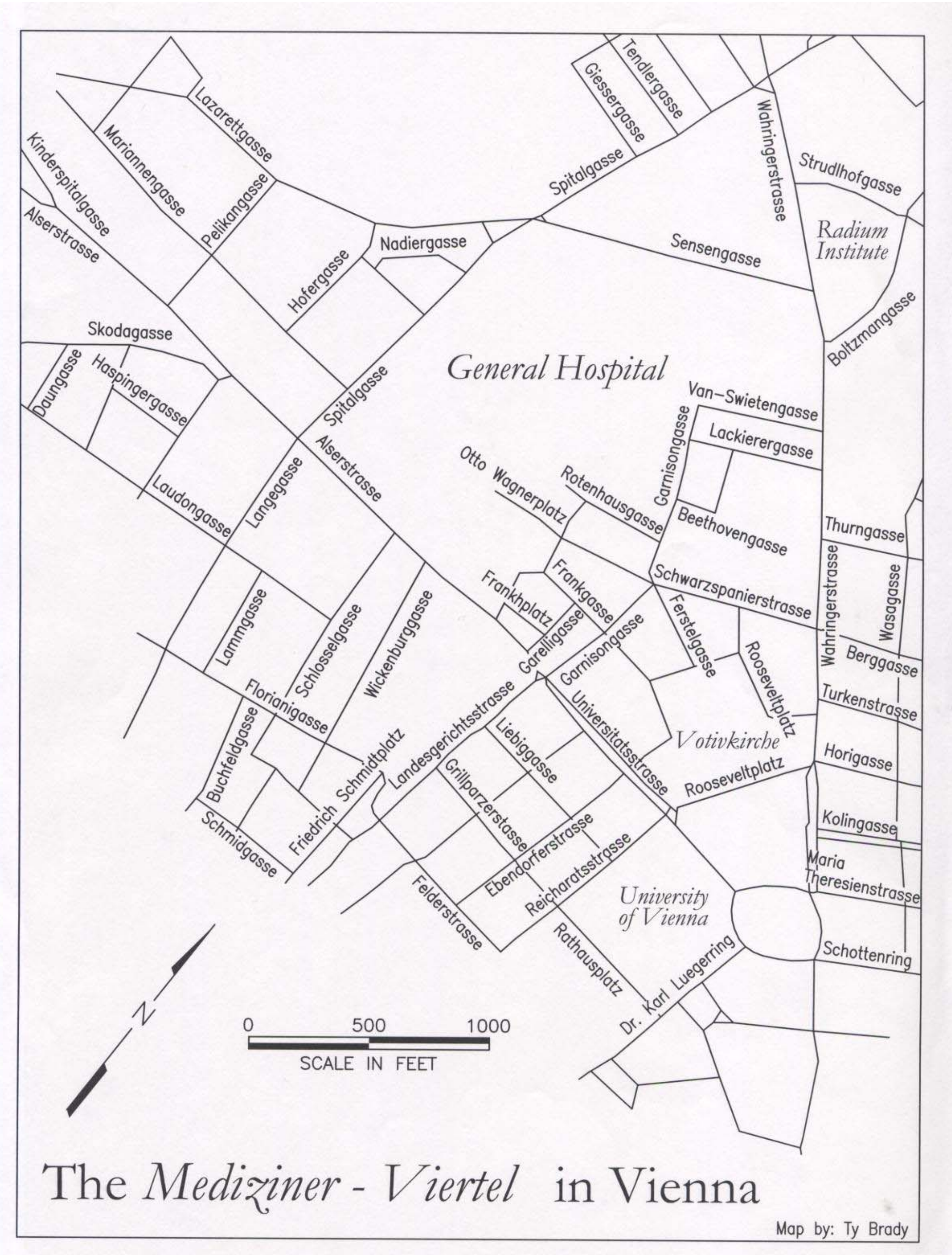
[1] Mach, *Populär-wissenschaftliche Vorlesungen,* (1910), p. 355.
[2] Mach, *Populär-wissenschaftliche Vorlesungen,* (1910), p. 355.
[3] Bischof, *Frauen am Wiener Institute,* (2000), p. 23.

But while myths exaggerate the unique and fabricate history, they shadow the ordinary and the harsh reality. To understand how any cultural meanings are constructed and fields of knowledge are developed, to surpass the myth, I focus on the politics that produce them. As Carl Schorske argues about the Viennese intellectuals, "the writers of the nineties were children of a threatened liberal culture."[4] Establishing their power in a struggle against aristocracy, liberals had their heydays between 1860 and 1880. By 1900 new political forces such as feminists, Social Democrats, and the anti-Semitic Christian Socials had already gained enormous political influence. Before the end of the century women were finally accepted to the University of Vienna because of persistent petitions and campaigns by feminists, supported by the Social Democrats, and despite the counteractions of the Christian Socials. Although defeated by the new political forces, the liberals had already provided the space around which the new social and political powers could evolve. The feverish urban reconstruction of the late 1880s and 1890s had created potential spaces of cultural and scientific activity in the margins of Ringstrasse.

If the oldest historical parts of the inner city were identified with the nobility of the aristocrats, the area around the new University and outside the Ringstrasse became the new concentrated center of an *in vivo* cultural and epistemic laboratory. In the ninth district of Vienna, a triangular piece of land known as the *Mediziner-Viertel* located behind the *Votivkirche*, between Wäringerstrasse and Alserstrasse, nurtured the reformists. Science and culture, politics and philosophy encountered one another in a small quarter, all within a fifteen minute walk. The spatial proximity of multidisciplinary research and teaching centers interspersed in a crowded residential area and the symbiosis of medical with Chemistry and physics institutes within the *Viertel* provided a unique opportunity to the Viennese scientific community in a number of respects. I emphasize this uniqueness here by following the history of the politics that produced it.

[4] Schorske, *Fin-de-siècle Vienna,* (1980), p. 6.

Figure 2.1 The *Mediziner- Viertel* in the ninth district of Vienna (Courtesy Ty Brady)



2.1. The University of Vienna

After the failure of the liberal revolution in 1848, in which the university faculty and students played an essential role, the imperial army of the Habsburg Empire occupied the old university in the inner city.[5] As a result institutes were scattered in the outer districts presenting the university with a disciplinary diaspora. The aim was twofold. On the one hand the Emperor aimed to dispel the intellectuals and enfeebling their political influence. On the other hand, expelling them from the inner city was a strategy for ensuring aristocrats' safety from any revolutionary threat.

During the 1850s Vienna experienced an immense economic growth. Economic enterprises doubled, as did the population of Vienna. The textile industry became the main financial source for the empire and attracted a considerable number of workers from the countryside. In 1857 the Emperor Franz Joseph I took the initiative to extend the inner city of Vienna, decreeing that the military area around it be converted to civilian use. Meanwhile, liberals gained more political power. One of their first concerns was the architectural transformation of the city. The core of the urban reconstruction was the Ringstrasse.

A sixty-foot-wide tree-lined boulevard in the shape of a ring replaced the walls around the inner city of Vienna. The Ringstrasse became the symbol of urban development, where besides the Imperial family and aristocrats, the newly emerging bourgeoisie fulfilled its expectations. For example, textile manufacturers belonged to the group with the second high ration of home owners in the Ringstrasse area after the nobility. As Schorske argues, "the art of building, used in the old city to express aristocratic grandeur and ecclesiastical pomp, now became the communal property of the citizenry, expressing the various aspects of bourgeois cultural ideal in a series of so-called *Prachtbauten* (buildings of splendor)."[6] The *Votivkirche*, the *Rathaus* (City Hall), the *Parliament*, the *Opernhaus* and other monumental buildings along the Ring indicated their purpose by their impressive architecture: parliamentary government, municipal autonomy, dramatic art, and liberal ideas.

Count Leo Thun-Hohenstein, the minister of education and religion, took a special interest in restoring the scientific and administrative autonomy of the university. In doing so Thun proposed not only reform of the curriculum, but also an

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[5] Schorske, *Fin-de-siècle Vienna,* (1980), p. 27.
[6] Schorske, *Fin-de-siècle Vienna,* (1980), p. 31.

architectural grouping of all university faculties and administrative offices. At the time, part of the medical faculty was located in the *Josephinum* at Wäringerstrasse and later in the old artillery industry in the corner of Schwarzspanierstrasse and Wäringerstrasse, behind the *Votivkirche* in the ninth district. The Chemistry Institute was located in the *Therasianum* in the other side of the city in the third district.[7] Bringing the University out of such a disciplinary diaspora, Thun's plan was to group several buildings around the main university site and create a *civitas universitatis* in Gothic style. In 1853, along the same lines, two of the most important architects of the time, Eduard van der Nüll and August von Sicardsburg, proposed a neo-Gothic design for the university just behind the *Votivkirche*. They designed a complex of four buildings arranged around two inner courtyards. The first and main building hosted the philosophical faculty and faculty of law, lecture halls, and administration offices. The library was located in a separate building as were the Chemistry and the Physics Institutes. A sacred edifice functioned as the University's church.[8]

By grouping all the university facilities and faculties around the main courtyards, Nüll and Sicardsburg satisfied Thun's ideal of a *civitas universitatis,* an English- and Gothic-style university quarter. The architect Heinrich von Ferstel, having designed already the Gothic-style *Votivkirche,* objected to positioning two monumental buildings so close to each other.[9] Because of the obstructionism of the City, lack of money, and the objections of the architect, for the next fifteen years Thun and his collaborators worked in vain to create the new university.

While the liberals were gaining political power, the university, as a symbol of liberal culture, occupied their interest. In 1868 the Mayor of Vienna, Kajetan Felder, formed a commission with three architects in order to design the *Rathaus*, the *Parliament* and the university building.[10] Ferstel was assigned to provide the site plans for the University. Different locations were considered since the new liberal ideal was a *Universitätsviertel* instead of the medieval *civitas universitatis*.[11] The aim was also to accommodate the *Allgemmein Krankenhaus* (general hospital), which was located between Alserstrasse and Wäringerstrasse, into the University quarter. Several locations were proposed but the committee insisted on one inviolate condition: the

[7] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p. 44.
[8] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p.45.
[9] Plassmeyer, "Nineteen Century Architecture," (1999), p.193.
[10] Schorske, *Fin-de-siècle Vienna,* (1980), p. 39.
[11] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p. 46.

main university building had to be located "within ten minutes from any building to another one."[12] Set up so that it was open to the city, but sufficiently close together to facilitate the work of the faculty and students, the new university finally acquired its position on the prestigious Ringstrasse. As Schorske skillfully points out, "Count Thun's plans for a medievalizing *cité universitaire*, with Gothic buildings huddled about the Votivkirche like chicks around a mother hen, faded with the new-absolutist politics that had given them birth."[13] The modern humanistic ideal of education was now indicated alone in the university plans that Ferstel designed in 1868. The Italian universities and their Renaissance architectural style offered Ferstel a model for the University of Vienna. In 1871 he traveled to Italy, visiting the "cradle of modern humanistic learning," the traditional universities of Bologna, Genoa, Padua, and Rome.[14] Thirteen years later the university finally opened its doors to the first students.[15]

2.2. Scientific Sites in the *Mediziner-Viertel*

The most important scientific sites around the university were the medical institutions of the city of Vienna. On Währingerstrasse, as Karl Przibram put it, "are the hospitals, in which the fame of the Viennese medical school lives on."[16] As early as 1783-84 the Emperor Joseph II, impressed by the Central Hospital in Paris, commissioned his architect Isidor Canevale to design Vienna's *Allgemein Krankenhaus,* grouping smaller hospitals into one extensive complex. Besides the main hospital building there was a maternity wing, an asylum, an infirmary, and a foundling hospital, all in separate edifices around several courtyards.[17] As the most modern hospital complex in Europe, the *Allgemein Krankenhaus* attracted the attention and interest of the medical world. The *Josephinum*, the building of the surgical and medical faculty and part of the hospital, was located at Währingerstrasse

[12] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p. 47.
[13] Schorske, *Fin-de-siècle Vienna,* (1980), p. 39.
[14] Schorske, *Fin-de-siècle Vienna,* (1981), p. 40; see also Flevaris, *Universität*, (2001), p. 2; Wibiral and Mikula, "Heinrich von Ferstel," (1974), p.57.
[15] Flevaris, *Universität*, (2001), p. 2.
[16] Przibram, "Erinnerungen," (1959), p. 1.
[17] Plassmeyer, "Nineteen Century Architecture," (1999), p. 154.

25. It was originally designed to accommodate army surgeons who did not have medical degrees but were organized in craftsmen's quilds.[18]

During the second half of the 19th century the hospital was repeatedly expanded.[19] Between 1868 and 1910, a number of new medical institutes and clinics acquired their position in the university quarter. In 1882 the *Sanatorium Löw,* later known as *Sanatorium Wiener*, one of the largest private hospitals in the capital, was founded at Mariannengasse 20, in the vicinity of the *Allgemmein Krankenhaus* and the Polyclinic.[20] The Anatomical Institute opened up its doors in 1888 at Währingerstrasse 13. In 1904 the Physiological and Pharmacological Institutes were established on the same building and four years later the Hygienic Institute opened up at Kinderspitalgasse 15, a street that crossed Alsertsrasse close to the hospital. From 1904 to 1911, new university clinics were built at Spitalgasse 23, a street crossing both Alsertsrasse and Währingerstrasse, forming a triangle on the back east side of the University. The Röntgen department of the Viennese Polyclinic became the first independent x-ray department in Austria in 1904. The Röntgen Laboratory of the second Medical University Clinic of Vienna had already been founded in the late 1890s.[21]

The architectural grouping of medical institutes in the university quarter contributed to the strengthening of the community of medical practitioners and university professors. As was common, the directors of the institutes lived in the institute with their families. Working and living at the same place provided better control of their assistants and students, and of the work done in the laboratories. It was out of the symbiosis of residential and professional space that the new cultural and epistemic *Viertel* emerged.

The reputation of Viennese medical scientists was without precedent. At the turn of the century the medical faculty was the only one that had a considerable number of foreign students who came to study under such leading physicians as the surgeon Theodor Billroth, the anatomist Joseph Hyrtl, and the physiologist Ernst

[18] Wyklicky, "Das Institut für Geschichte," (1990), p. 3.
[19] For the history of medicine in Vienna see Wyklicky, "Zur Entwicklung," (1986), pp. 35-41; Fischer, *Geschichte der Gesellschaft der Ärzte,* (1938); Neuburger, *British Medicine and the Vienna School,* (1943).
[20] As Janik and Veigl demonstrate, the sanatorium was one of the leading private hospitals for surgery, "part of the elegant life style of the patrician class of that time" (Janik and Veigl, *Wittgenstein in Vienna,* (1998), p. 153).
[21] Kogelnik, "The History and Evolution of Radiotherapy," (1996), p. 222.

Brücke.[22] Thus, it is not fortuitous that for the area around the university the name that prevailed was the *Mediziner-Viertel*, the doctors' quarter, rather than the *Universitätsviertel,* the university quarter.

2.3. The Chemistry Institute

The main university building, however impressive and monumental it was, offered space only for administration offices and teaching facilities. All the rest had to occupy separate buildings around the same area, realizing the plan for a university quarter. The institute of greatest priority was that of chemistry (1869-72).[23] On the one hand, the *Theresianum,* the building where the Viennese Chemistry Institute had been housed since the end of 1860s, was insufficient for research purposes. The small and cheaply built laboratory was able to host only 60 students. On the other hand, the institute was located far away from Vienna's medical institutions. As the teaching of chemistry was mainly targeted to medical students, common theme of the Viennese press was the student's complaint of being unable to attend classes given the long distance between the hospital and the Chemistry Institute.[24] At the same time, the nature of chemistry was changing drastically. The shift from inorganic to organic chemistry gave way to fruitful experimentation and created the demand for bigger research laboratories.[25]

Not surprisingly, Joseph Redtenbacher, Professor of Chemistry, member of the Viennese medical faculty, and director of the Chemistry Institute together with his colleagues voiced their demands for a modern edifice. As Brinda-Konopik mentions, their persistent attempts for a new institute close to the main university were not in

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[22] May, *The Hapsburg Monarchy,* (1965), p. 319.
[23] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p. 49. As Jeffrey Johnson argues for the case of Germany, between 1866 and 1914 chemistry was the first among all disciplines in the philosophical faculties, to acquire its own institute. The German chemical industry, particularly the coal-tar dye one, and the demands from fields like pharmacy and medicine for workers with chemical training, justified the government's investment (Johnson, "Academic Chemistry," (1985), p. 501. See also Meyer-Thurow, "The Industrialization of Invention," (1982), pp. 363-381). In case of Vienna the situation was similar. The textile industry, the most prosperous industry in Austria, required chemists as well. (See Schorske, *Fin-de-siècle Vienna,* (1980), pp. 58-59; Okey, *The Habsburg Monarchy,* (2001), pp.229-233).
[24] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p. 49.
[25] Michl, *Geschichte des Studienfaches Chemie,* (1950), p. 62. On the shift from inorganic to organic chemistry see Johnson, "Academic Chemistry," (1985), pp. 500-524.

vain.[26] Based on Ferstel's Renaissance design, the new Chemistry Institute acquired a location within the university quarter at Waehringerstrasse 10, a few blocks away from Ringstrasse and next to the *Votivkirche*.

The idea of a separate experimental laboratory for chemistry was drawn from the well-established institute (1828) in Giessen, Germany. Redtenbacher and Ferstel traveled to Germany in order to visit chemistry institutes in Heidelberg, Bonn, Berlin, and Leipzig before they decided on the final plans for the one in Vienna.[27] The decisive characteristic for choosing the German model as a guide for designing the institute in Vienna, was its uniqueness in including three spatially isolated facilities under the same roof: lecture halls, laboratories, and an apartment, usually on the ground floor, for the person taking care of the building.[28] Often the director of the institute was offered a free apartment on the upper floor of the building as part of his appointment agreement. Besides supplementing the low salaries of the time, the symbiosis of teaching, research, and residence offered to the directors the ability to have absolute control over their institutes and their assistants. As research occupied an even greater proportion of the chemists' interest, teaching was no longer their only priority.[29] Chemical experiments could often run for hours, even until late the night, and both students and assistants were in and out the laboratory constantly.[30]

Apparently, the location of the Chemistry Institute in the *Mediziner-Viertel* reflected not only the political changes that made possible the design of the university quarter in the first place but also changes in the culture of science. The shift was underway from teaching-oriented institutes with limited working space to institutes that combined research facilities with modestly advanced educational laboratories and lecture halls designed to accommodate a large number of students. Redtenbacher was the first who took advantage of the political changes, using the enthusiastic support of the liberals for humanistic education as a lever to alter the culture of chemistry. Eventually, the impressive Renaissance-style Chemistry Institute on Währingerstrasse

[26] Brinda-Konopik, "Robert Willhelm Bunsen," (1992), pp.3-4.
[27] Brinda-Konopik, "Robert Wilhelm Bunsen," (1992), p. 2.
[28] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p. 49.
[29] Although research and experimentation were gaining the interest of the chemists, Redtenbacher continued to focus on and value immensely teaching. For instance, in one year he visited 590 lectures and went to 360 exams (Brinda-Konopik, "Robert Wilhelm Bunsen," (1992), p. 4).
[30] The Viennese Chemistry Institute provided a unique addition to the German architectural tradition. Paying attention to the suggestions of the director Redtenbacher, Ferstel included not only the director's residence in his plans, but additional professorial apartments as well. Cost overruns raised questions about the usefulness of this peculiarity (Michl, *Geschichte des Studienfaches Chemie,* (1950), pp. 61-2).

reflected not only Ferstel's flexibility to accommodate changes in political power in his architectural style, but also both his and Redtenbacher's ability to incorporate and support the new scientific culture. Big lecture halls, spacious laboratories, and professorial apartments were grouped under the same roof. In their architecture, they embodied the complex task of bringing together different disciplines and therefore, several professors as well.

By locating the Institute in the *Mediziner-Viertel* within walking distance—less than five minutes—from the Viennese medical institutions, students were able to attend one lecture after the other with no delay. At the same time the interdisciplinarity of chemistry was reflected in the education and research of the Institute's chemists. Starting from Redtenbacher, all the directors of the laboratories housed in the Chemistry Institute combined pharmaceutical, medical, and chemical expertise deploying their knowledge of each ones field in the others.[31] Franz Cölestin Schneider, a pharmacist and medical chemist, and later Redtenbacher's successor, argued that the institute should be designed so as to cover the purposes and needs of pharmacists.[32] The interrelation of chemistry and medicine was also reflected in the journals of the time. For example, one of the most prestigious periodicals the *Annalen der Chemie und Pharmacie,* combined both pharmacy and chemistry in its title and content. Chemistry was obviously in the crossroads of pharmacy and medicine. Most of the chemists' teaching was indeed done for medical students. This was evident in the fact that after the Institute's establishment, besides the 300-400 students of chemistry that attended lectures, 100 more pharmaceutical and medical students crowded into the lecture halls.[33]

The splendid new Chemistry Institute opened up its doors in 1872. Although originally designed with capacity of 140 students in its laboratories and 400 students in the big lecture hall, it turned out to be too small. Chemistry was rapidly expanding and already in 1870 a second professorship was established.[34] The physicists,

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[31] Redtenbacher was actually professor of Chemistry in the medical faculty of the University of Vienna (Brinda-Konopik, "Robert Wilhelm Bunsen," (1992), p. 2).

[32] Michl, *Geschichte des Studienfaches Chemie,* (1950) p. 62. Before Schneider accepted his position as director of the second Chemistry Laboratory, he was the director of the Chemistry laboratory in the *Josephinum,* the medical school for military physicians (see Schönfeld and Ipser, "Die Geschichte der Chemie," (1996), p. 1).

[33] Brinda-Konopik, "Robert Willhelm Bunsen," (1992), p. 5; Michl, *Des Geschichte des Studienfaches Chemie,* (1950), p. 61.

[34]In the Chemistry Institute at Währingerstrasse 10, there were located two distinct laboratories, the first and second Chemistry Laboratory. They had different directors, who both held chairs of chemistry at the University of Vienna. The establishment of the second lab took place right after Redtenbacher's

nonetheless, had to wait a long time to realize their claims to a significant site for their own institute.

2.4. The Physics Institute

The Physics Institute (*Physikalisches Institut*) was housed in Erdbergstrasse, in Vienna's third district close to the *Theresianum*. Honorable enough that it hosted the *Physikalisches Kabinett*, the private collection of the Habsburgs' scientific instruments, machinery, and curiosities, it was totally insufficient for the number of students attending physics courses.[35] The museum-like collection did not satisfy the research needs of the physicists either. As Ludwig Boltzmann later recalled, "We always had plenty of ideas and were only preoccupied with the lack of apparatus."[36] In 1865, Victor von Lang, a Viennese physicist who had worked with Michael Faraday in London, became the director of the *Physikalisches Kabinett* and succeeded in improving the Institute's extremely modest conditions acquiring new apparatus.[37] In 1872, the medical faculty introduced experimental physics as a new, two-semester course requirement for its students and Lang engaged in teaching it. His lectures were soon overcrowded. Lang finally arranged to lecture in the *Josephinum* and moved his apparatus to the big lecture hall, saving his students from commuting.[38] Obviously there was a high necessity for physics lectures and laboratory work for the medical students. While Lang's course evolved into one of the most well-attended lectures, it consequently provoked the urgent demand for more apparatuses and restructuring of the course so as to meet the needs of the medical students. Shortly after, Lang received an endowment of 4500 florins, a considerable amount for the time, and an assistant position.[39]

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death in 1871. His successor was the pharmaceutical and medical chemist Franz Schneider while Friedrich Rochleder, a student of Redtenbacher, became the director of the second institute. (see Schönfeld and Ipser, "Die Geschichte der Chemie," (1996), p. 1; Brinda-Konopik, "Robert Wilhelm Bunsen," (1992), p. 5).

[35] Przibram, "Errinerungen," (1959), p. 2; Reiter, "Vienna: A Random Walk in Science," (2001), p. 463.

[36] Cercignani, *Ludwig Boltzmann,* (1998), p. 6

[37] Reiter, "Vienna: A Random Walk in Science," (2001), p. 466. In 1872 Lang was able to obtain the considerable amount of 1210 florins and an annual donation of 1000 florins. (Hittner, *Geshichte des studienfaches Physik,* (1949), p. 58.)

[38] Karlik and Schmid, *Franz Serafin Exner,* (1982), p. 38; Hittner, *Geshichte des studienfaches Physik,* (1949), p. 58.

[39] Hittner, *Geshichte des studienfaches Physik,* (1949), pp. 58-59.

Facing similar issues as the chemists, the physicists expected similar treatment. They were obviously after a new institute, preferably located in the *Mediziner-Viertel*. Amid Redtenbacher's negotiations, Josef Stefan, the director of the Physics Institute (*Physikalisches Institut*), and Ernst Brück, director of the Institute of Physiology, agreed to establish their own laboratory at the corner of Hörlgasse and Währingerstrasse. The same year that Lang moved to the *Josephinum* and after the Chemistry Institute was opened, Ferstel submitted his plans for the new institutes of physics and physiology as a continuation of the *Universitätsviertel* project. The longer side of the building was attached to the Chemistry Institute and several halls permitted communication among them.[40] The plan was to facilitate teaching and laboratory work but also to encourage research and exchanges among the different institutes. The interconnection of both physics and chemistry to medicine and pharmacy and the dependence of the prestigious medical students on chemists and physicists for their education offered the latter a similarly prestigious location within the university quarter.

In the meantime and when both the University and the Chemistry Institute were built, natural scientists vigorously reacted to the massive, monumental, and impressive style of the new university. As they argued, a simpler architecture could fit better the plain and austere nature of their sciences. In a faculty petition on August 4, 1871, they claimed that the new buildings, by resembling the architecture of the Italian universities did not serve the purpose of furthering the natural sciences. "These flowered elsewhere in the universities of Berlin and Munich, in the Polytechnic of Zurich, in the Collège de France in Paris, and in the Kings College in London, where the exact science can feel comfortable. Fewer floors of the same height, several but larger courtyards, all straight lines fitting to austere requests."[41]

One of the most politically flexible architects of his time, Ferstel for once faced resistance from conservative scientists and not politicians. Caught between obstinate natural scientists and the crash of Austria's stock market in 1873, Ferstel's plans were never realized. Instead, in 1875 the university purchased a block of flats and converted it to an institute. Both Lang's *Physikalisches Kabinett* and Stefan's *Physikalisches Institut* moved into a four-story building located in Türkenstrasse 3, a short side street crossing Währingerstrasse. The Physics Institute turned out to be

[40] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p. 49.
[41] Wibiral and Mikula, "Heinrich von Ferstel," (1974), p. 61. (translation mine)

insufficient for both teaching and research, a "very primitive, converted apartment house,"[42] as Lise Meitner described it, a "miserable space"[43] interspersed among the residences and shops of the neighborhood. Karl Przibram, a physicist and later assistant of the Institute for Radium Research recalled that:

> The inner space was not designed as a laboratory. At the time the lecture halls were not suitable for lecturing, they were quite ramshackle and the ceiling beams that were covered with, were already rotten. I preserved for a long time as relic a small piece of such ceiling beams, that looked like as if it had been chewed by termites."[44]

The use of the lecture hall was dangerous and often the Viennese press was occupied by the case of the Physics Institute. The daily *Arbeiterzeitung,* a Social Democratic paper, satirized the shabbiness of the building, reporting "Once again a student has registered in the Physics Institute on the Türkenstrasse; unhappiness in love is said to be the motive for the deed." [45] In the big lecture hall there were no desks and the students had to write on their knees. The floor was so rickety that it quivered whenever one crossed the room and apparatuses sensitive to motion could not be operated.[46] Later, when Meitner entered the University of Vienna and attended a physics course at the Institute, she expressed fear that if a fire broke out, very few could actually survive.[47]

In Türkenstrasse and under the same roof on the third floor was located the Institute for Physical Chemistry. Already in 1867 Redtenbacher, Lang, and Stefan proposed the establishment of a professorship of physical chemistry. At the time, Josef Loschmidt was working on gas theory, combining chemistry and physics in his research. He collaborated closely with Stefan and used the facilities of the Physics Institute when that was still housed in Erdbergstrasse.[48] Thus, it is not surprising that the physicists suggested Loschmidt as the most appropriate person for the position in physical chemistry.[49] He soon became director of the Institute of Physical Chemistry and his lectures attracted 100 to 120 students regularly. In his laboratory courses,

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42 Meitner, "Looking Back," (1964), p. 4.

43 Bendorf, "Worte der Erinnerung an Franz Exner," (1926), p. 2, Nachlass Exner, AÖAW.

44 Przibram, "Erinnerungen," (1959), p. 1. (translation mine)

45 The *Arbeiterzeitung* was among the newspapers that openly supported the Social Democrats (see Rabinbach, *The Crisis of Austrian Socialism*, (1983), p. 27). Karl Przibram was the one who recalled the incident (Przibram, "Errinerungen," (1959), p. 1).

46 Benndorf, "Gedenkrede auf Franz Serafin Exner," (1937), p. 7, Nachlass Exner, AÖAW.

47 Sime, *Lise Meitner,* (1996), p. 11.

48 Karlik and Schmid, *Franz Serafin Exner,* (1982), p. 33.

Loschmidt had around twenty students as trainees. His physics course, designed for pharmacists, had the highest attendance.

While physical chemistry began to challenge the traditional boundaries of both physics and chemistry, the directors of the Physics and Chemistry Institutes tried to preserve their collegiality. Close intellectual exchange determined the work at Türkenstrasse where the physics community of *fin-de-siècle* Vienna mingled with chemists and was occupied with exciting scientific research. As Przibram later recalled with nostalgia about that "idyllic time," "the young generation of physicists can hardly imagine the passion of the debates, echoed in those days, particularly in the above mentioned coffee house."[50] The "above mentioned coffee house" was a coffee house at the corner of Währingerstrasse and Türkenstrasse, one of the distinct Viennese cultural spots, which literally housed the young physicists of the Institute.[51]

Indeed, the Viennese culture of *Kaffeehäuser* contributed its part to the confluence of scientific disciplines and identities.[52] Symbol of carefree existence, the Viennese coffee house carried a paradox: it reflected the hard realities of life in Vienna at the same time that it seemed to embody a relaxed way of spending a day by reading the papers and enjoying the delicious pastries. Due to the housing shortage the working class apartments were small, inadequate, and unbearable especially during the cold Viennese winters. Coffee houses offered a pleasant and warm environment throughout the day. The same architectural absurdity led the physicists working at Türkenstrasse to the charming coffee house at the corner of their laboratory.

2.5. Franz Exner's Circle and his Ethos of Working in Physics

At the turn of the century the physics community was marked by the reorganization of its institutes and big cuts in their finances.[53] In 1902 the *Physikalisches Kabinett* was renamed to *I. Physikalisches Institut* and Lang remained its director. The *Physikalisches Institut* that Stefan directed until 1894 was renamed to

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[49] For the establishment of the Institute for Physical Chemistry the government offered the generous endowment of 6400 florins and an annual donation of 800 florins (Hittner, *Geshichte des studienfaches Physik,* (1949), p. 60).
[50] Przibram, "Erinnerungen," (1959), p. 2, 5.
[51] Przibram, "Errinerungen," (1959), p. 1.
[52] On the Viennese culture of coffeehouses see Heering, *Das Wiener Kaffeehaus* (1993); Heise, *Kaffee und Kaffee Haus*, (1989).
[53] Cercignani, *Ludwig Boltzmann,* (1998), p. 30.

Institut für theoretische Physik and Boltzmann became the director.[54] Loschmidt's Institute of Physical Chemistry was renamed to *II. Physikalisches Institut* and Franz Serafin Exner took over the directorship. Given the reorganization of the physics institutes Boltzmann's apartment in the building at Türkenstrasse was ceded to Exner's Institute as working rooms.[55] The collection of scientific instruments formerly belonging to the *Physikalisches Kabinett*, was now transferred to Exner's supervision.[56] At the time Exner was *Ordinarius Professor* at the University of Vienna and one of the most prominent experimental physicists, in charge of a considerable number of students. Research on atmospheric electricity, color theory, spectral analysis, and radioactivity occupied his interest. Open to scientific challenges, he was the first to report Konrad Röntgen's discovery of x-rays on January 7, 1895, to the Institute for Physical Chemistry in Vienna.[57]

Exner's earlier career started in Strassburg. Disappointed by the monolithic culture of the physics community there, he returned to Vienna. As he complained, "Day after day from 8:00am to 10:00pm physics and again physics, this no decent human could stand."[58] What Exner missed, as Berta Karlik and Erich Schmid explained, was Viennese culture and art, especially music. And it was this culture that Exner instilled in the physics community of Vienna in his return. As best described by his assistant Hans Benndorf, Exner established a new ethos for working in physics:

> A circle of like-minded friends, we surrounded our admirable and beloved teacher as a big family. The most wonderful and also cheerful hours of the day were the tea at the Institute during late afternoon, the "little father," this is how we .., with his pipe in his hand regularly presiding. There we were talking about God and the world, often

[54] In 1894 Boltzmann succeeded Stefan as director of the *Physikalisches Institut*. In 1900, dissatisfied with political and professional conditions in Austria, he accepted an appointment as Professor of Theoretical Physics in Leipzig. He returned to Vienna in 1902 (Hittner, *Geshichte des studienfaches Physik,* (1949), pp. 64-65; Cercignani, Ludwig Boltzmann, (1998), pp. 28-9).

[55] Reiter, "Vienna: A Random Walk in Science," (2001), p. 471. Between 1894 and 1900 Boltzmann, as director of the *Physikalisches Institut*, was also responsible for conducting laboratory courses. Because of the load of his own research he asked to be excused from the above duty. Exner was the one who had to take over the responsibility. Over and above his own laboratory courses in physics, Exner was obliged to direct Boltzmann's as well. The odd situation ended when Boltzmann left Vienna accepting the position in Leipzig. On his return in 1902 the rearrangements of the physics laboratories brought into light the old tension between Exner and Boltzmann, creating the only exceptional case of a conflict between colleagues at Türkenstrasse (Cercignani, *Ludwig Boltzmann,* (1998), pp. 28-30).

[56] Reiter, "Vienna: A Random Walk in Science," (2001), p. 471; Lintner and Schmid, "Das II. Physikalisches Institut," (1965), p. 379; Karlik and Schmid, *Franz Serafin Exner,* (1982), p. 65.

[57] Karlik and Schmid, *Franz Serafin Exner*, (1982), p. 63. Exner's close friendship with Röntgen went back to the time that he spent the third year of his studies in Zurich under the physicist August Kundt and later in Strassburg where both worked as *Assistentent* at the university.

[58] Karlik and Schmid, *Franz Serafin Exner,* (1982), p. 63. (translation mine)

> passionately discussed, and about controversial scientific questions. And we had good arguments with him, and he could bear any contradiction as long as it was not personal. Also we never felt his superiority and he always was a young between the young. We are indebted to those hours for the general promotion and important stimulation of our own work.[59]

Przibram recalled the same picture of Exner in his white lab coat and the inevitable pipe in his hand: "the picture reflects something from the cosiness that ruled the circle in those days."[60] Passionate debates on science and politics and Exner's narratives of his long trips to India, Greece, and Asia often accompanied by music, were carried on at his home on Währingerstrasse 29 every Saturday evening.[61] In his welcoming house right in the heart of the *Mediziner-Viertel* next to the *Josephinum,* Exner cultivated the Viennese ethos of collaborative work in physics and mentored nearly all the experimental physicists in Austria. His circle included Hans Benndorf, Egon von Schweidler, Stefan Meyer, Maria Smoluchowski, Friedrich Hasenöhrl, Karl Przibram, Felix Ehrenhaft, Erwin Schrödinger, and Hans Thirring among others.

"Exner's circle" [62] or "Exner's School"[63] as it is known, promoted not only the integration of physics with the Viennese culture but also the work of women in the field. Exner was among those professors who in 1893 formed a committee for the support of women's admission to the University of Vienna.[64] Despite the support of Exner and a number of liberal university professors, women's way to university admission had been long, and for some of those who went through it, very painful.

2.6. The Way to Women's Admission to the University of Vienna

During the 1860s the economic distress in Imperial Austria forced many women to search for employment. For example, the majority of workers in the textile

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[59] Benndorf, "Worte der Erinnerung an Franz Exner," (1926), p. 2, Nachlass Exner, AÖAW.
[60] Przibram, "Errinerungen," (1959), p. 3. (translation mine)
[61] Benndorf, "Worte der Erinnerung an Franz Exner," (1926), p. 1, Nachlass Exner, AÖAW.
[62] Karlik and Schmid, *Franz Serafin Exner,* (1982).
[63] Benndorf, "Worte der Erinnerung an Franz Exner," (1926), p. 2, Nachlass Exner, AÖAW.
[64] Bischof, *Frauen am Wiener Institut,* (2000), p. 23. Exner's brother, the physiologist Sigmund Exner, was married to Emilie von Winiwarter, a woman active in public life and in women's movement. At one point she became president of the Viennese Women's Employment Association (Karlik and Schmid, *Franz Serafin Exner*, (1982), p. 52). Her son, Felix Exner, studied physics with his uncle and participated in the circle of Franz Exner's friends. It is not surprising that Exner's family, due to their

industry were women.[65] Proliferating in these new professions, lower middle-class women needed special training in new technologies. In 1867 the *Viennese Women's Employment Association* (*Wiener Frauen-Erwerbverein*) emerged to cover such needs. Soon the leader Iduna Laube, having the absolute support of the Association, established a school for sewing linen and a commercial school with courses in embroidery, lace-making, dressmaking, and housekeeping. In 1871 the Association founded an academic school in the form of a *höhere Bildungsschule,* providing four years practical training. Mainly upper class women concerned to facilitate women's "entry into female white-collar employment" ran the school.[66]

Although the Association vehemently stressed women's right to education, it did not have any further political aims. The suggestion to establish a *Gymnasium* for girls, a school equivalent to that for boys aiming to university studies, was considered so revolutionary that none of the Association's women was willing to pursue it. Without challenging the conventional female identity of a housewife, their goal was to professionalize traditional female activities. A number of other vocational schools followed that of the Association's. However, not one of them was "suited to raise the level of education of girls from the middle-class intelligentsia and therefore to open profitable sources of income to them," as Marianne Hainisch, one of the prominent feminists of the time, argued.[67]

It was not until 1888 that the *Association for Extending Women's Education (Verein fuer erweiterte Frauenbildung)* was founded as an attempt to support the establishment of a *Gymnasium* for girls. The goal was not modest since the school could be the first one in Vienna to bring girls up to the academic standards necessary for university entrance. Thus, along with a petition for the establishment of the school, the Association handed to the Imperial government an appeal for the admittance of women at the arts and medical faculties of the University of Vienna. This was signed by 3,644 women members of a number of different Viennese associations and groups such as the *Association of Housewives* (*Hausfrauen Verein*) with 2,601 members, and the *Association of Teachers and Nursery School Teachers* (*Verein der Lehrerinnen*

strong beliefs in the liberal bourgeoisie ideal of education, supported women's admission to university studies and welcomed women students to the physics community.

[65] Barea, *Vienna,* (1966), p. 254.

[66] Anderson, *Utopian Feminism,* (1992), p. 26.

[67] Anderson, *Utopian Feminism,* (1992), p. 29.

und Erzieherinnen) with 600 members.[68] Women scientists from Germany joined the campaign and offered their experiences as invited speakers in the Association's protestations. The ophthalmologist Rosa Kerschbaumer and the surgeon Agnes Bluhm were among the first to support Viennese women's rights to education.[69] After all the franchise to enter the University as full students was the pivotal feminist demand, so central that it was presented as self evident in the feminist discourse of the time. "We believe," wrote the women signed the petition of 1890, "that women's right to scientific education needs no further evidence, but women's self functionality and opportunity."[70]

In a certain sense the appeal of the *Association for Extending Women's Education* was limited to a few thousand middle class Viennese women and probably directly affected only those who had the means to pursue private education. But in another sense their education reform campaign shaped the ideals of a number of young women who portrayed different personal expectations to their university admission. The association and its demands provided a crucial impetus for the transformation of Viennese culture and society. A collective new female identity emerged and traditional meanings of sexual difference were challenged. Since the Austrian government did not respond to the feminists' requests for educational changes, in 1892 the association opened up a private *gymnasiale Mädchenschule* based on the curriculum of the boy's gymnasium. Prominent intellectuals and officials such as the director of Vienna's training institute for gymnasium teachers, Emmanuel Hannak, supported women's educational initiative. Setting high standards from its establishment, the school was equivalent to the *akademisches Gymansium*, the one appropriate for preparing boys for higher education.[71]

The school was not established in a theoretical vacuum and apart from the feminist discourse of *fin-de-siècle* Vienna. The investigation of early Viennese feminist movements by Harriet Anderson changes the conventional picture of Vienna as merely the city of Sigmund Freud and Gustav Klimt, of music, art, and smoky coffeehouses crowded by the Viennese intelligentsia. "There was in fact a flourishing culture of political opposition in which men and women worked together for a vision of a society which could not dehumanize its members but permit them to go 'in

[68] Bandhauer-Schöffman, "Frauenbewegung und Studentinnnen," (1990), p. 50.
[69] Bandhauer-Schöffman, "Frauenbewegung und Studentinnen," (1990), p. 51.
[70] Bandhauer-Schöffman, "Frauenbewegung und Studentinnen," (1990), p. 54.

purity' through life, 'that means without concealment and without regret'."[72] The Viennese feminists played a crucial role in the formation of this culture of political opposition. In the last decade of the 19th century, an organized political feminist movement emerged in Vienna, interwoven to the broader cultural changes. The interplay of different cultural and philosophical critiques led to increasing political awareness. Women became part of the political game, bringing into focus ethics and sexual morality as well as women's rights and equal opportunities to education. Two autonomous feminists groups, the *General Austrian Women's Association* (*Allgemeiner Oesterreichischer Frauenverein*) and *the League of Austrian Women's Associations (Bund Oesterreichischer Frauenverein)* marked the Viennese feminist scene.

Auguste Fickert, a primary school teacher with a strong personality and radical ideas, was the leading figure of the *Women's Association*. Her views, extreme for the time, included the argument that changing external conditions alone could not be enough in changing women's lives. Better wages and equal rights for women in work and family were necessary but not sufficient without the "merging of intelligence with morality."[73] Both the *Women's Association's* and Fickert's main emphasis was on women's education, their intellectual awakening, and the raising of their consciousness.

By the end of the 19th century Social Democracy was taking serious steps towards those goals and Fickert was not oblivious to her allies. The Social Democratic Party emerged during the same period, bringing together a number of disparate and disorganized groups under the leadership the Marxist theorist Karl Kautsky and of Victor Adler who gave up his medical studies for politics. Founded in 1889 and based on Marxist principles, the Social Democrats aimed to reconcile ethnic conflicts between the Czech and German wings of the labor movement.[74] While they maintained their liberal heritage of enlightenment and were committed to cosmopolitanism, they put great emphasis on workers' pedagogical and cultural reform. Most of their activities were conducted in several languages, proving the internationalism of the labor movement.[75]

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[71] Bandhauer-Schöffman, "Frauenbewegung und Studentinnen," (1990), p. 54.
[72] Anderson, *Utopian Feminism,* (1992), p. 253.
[73] Anderson, *Utopian Feminism,* (1992) p. 11.
[74] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 10.
[75] Okey, *The Habsburg Monarchy,* (2001), p. 267.

The appeal of the Social Democrats to women was significant, especially since, by the end of 1890s, women working mainly in clothing industry, made up one quarter of all industrial workers in Vienna.[76] Groups of women music teachers, midwives, and actresses found their representation through Social Democrats while the first women's occupational groups found their own associations in the late 1870s. Unions of working women came later. The first one was founded in 1901 by women working as typists and officials in banks, post offices, and railways and in lower status jobs such as tobacco sellers and seamstresses.

In 1883, despite the high number of women's associations and organizations, Fickert called the founding meeting of the *General Association,* the first to deal openly with women's suffrage in Austria. Since Social Democrats were not radical enough to press for women's suffrage, Fickert insisted on the establishment of an autonomous women's association; she never formally supported the Social Democratic party.[77] Surprisingly advanced for this time, Fickert treated power as a complex network of economic, sexual, and social constraints imposed by the capitalist and bourgeois mentality about women. As a means of women's emancipation Fickert suggested the development of their personalities and their intellectual awakening. "By making women aware of all the power games which the present order of things means for them, namely economic, social, sexual bondage, [it] therefore leads women …by detour to the same goal that the women's movement attempts to reach directly."[78]

Marianne Hainisch and the *League of Austrian Women's Associations* (*Bund Oestereichischer Frauenverein*) that she established in 1902 had less ambitious and radical goals. The wife of a cotton-factory owner, Hainisch founded the *League* as part of the international feminist network based on the principles of the International Council of Women. It functioned as a public relations body of the Austrian women's movement and united a number of associations, attempting to support and not compete with them. Adopting the discourse of equality and difference, Hainisch fought for the equality of women and men, stressing their differences without challenging the status quo of power relations. One of the strongest advocates for a women's *Gymnasium*, she envisioned education as women's means to enter better

[76] Barea, *Vienna,* (1966), p. 335.
[77] Although Social Democrats emphasized the need to change the laws that excluded women from any political activities, this was not among their first priorities (Gay, *Freud: A Life of Our Time,* (1988), p. 510).
[78] Anderson, *Utopian Feminism,* (1992) p. 12.

professions. Hainisch and the *League* strongly emphasized their apolitical character and they argued less in terms of women's rights and emancipation than in terms of morality. Despite their differences, Hainisch and Fickert had one common goal, that of women's *Bildung*. Along with the *Association for Extended Women's Education,* the *League* organized a number of talks inviting male intellectuals to speak about women's rights from a philosophical, historical or juristic point of view.

Men played a significant role in the middle-class women's movement. A number of university professors, artists, and left-wing middle class intellectuals supported the women's movement, spoke at their meetings, joined their associations, and offered their expertise for the improvement of women's education. In 1900 the historian Ludo Moritz Hartmann and the *Union of Austrian University Teachers* initiated an association known as *Athenäum: Association for the Holding of Academic Courses for Women and Girls.* Julius Tandler, anatomist at the University of Vienna and main figure in the Social Democratic Party later in the 1920s, offered free lectures. The zoologist Carl Brühl lectured on natural sciences in a seminar room flooded with women. The philosopher Friedrich Jodl was one of the most passionate supporters of women's education along with his wife Margarete Jodl, president of *Vienna Women's Club (Wiener Frauenclub),* a cultural network of upper class Viennese women.[79]

Unique in this story is that of all the physics communities in Austria only the one in Vienna played an essential role in promoting women's education at the academic level.[80] Lang, firmly convinced that women should not be held back from studying at the university, welcomed them to his lectures before they were officially accepted as formal students.[81] Boltzmann supported the *Association for Extended Women's Education* by his full membership. When around the mid-1870s Henriette von Aigentler, the woman who later became his wife, was refused permission to unofficially audit lectures at the University of Graz, Boltzman prompted her to appeal.[82] Aigentler did, successfully, but only for one semester. The following semester the philosophical faculty approved a rigid rule to exclude women from their

[79] Anderson, *Utopian Feminism,* (1992), p. 113; On Friedrich Jodl see also Korotin, "Auf Eisigen Firnen," (1997), p.292.
[80] Based on her unpublished data and research, Brigitte Bischof argues that the participation of women in physics at the University of Vienna was much higher than, for example, that at the University of Graz. The support of the physics community made the case of Vienna unique within Austria. (personal communication with Bischof).
[81] Bischof, *Frauen am Wiener Institut,* (2000), p. 23.

lectures at the University of Graz.[83] Later their daughter, Henriette Boltzmann, was one of the first who took the *Matura*—exams for university entrance—in 1901.[84]

The above instances of the support by academics of women's right to be admitted to the university and for attempts to reform their everyday lives indicate that in the late 19th century the forging of a new identity for women was underway. This identity was generated through feminist discourse and was expressed and traced in journals such as the *Dokumente* and the *Neues Frauenleben,* both organs of the autonomous feminist groups. The feminists attempted to alter women's lives and envisioned them as intellectuals, socially active, enjoying conversations and reading. Thus, when in 1896 women were finally granted the permission to sit for the *Matura*, they embraced the chance. Since the only women's *Gymnasium* in existence did not have the license to set up its own exam, women had to sit as *Externisten* (outside students) in one of the *Gymnasiums* for boys under strenuous and unpleasant conditions. "We were fourteen girls in all," Lise Meitner recalled, "and took a not altogether easy exam (only four of us got through) at a boys' school, the *Akademisches Gymnasium* in Vienna."[85] Despite the frustrations women were finally accepted to the philosophical faculty of the University of Vienna in 1897 and three years later the doors of the medical and pharmaceutical faculty of the university opened for them.[86]

While feminists were struggling for university admission, the Christian Social Party elected Karl Lueger in 1890 as its leader. The great depression of 1873 and the crash of the Austrian stock market led to dissatisfaction with the liberals. At the same time the labor movement was in disarray and unable to play a serious political role. It was also the time that Lueger switched his political alliances. Earlier in his political career, Lueger had drawn heavily on his experience as a liberal and used as his ally the Jewish Social Democrat Ignaz Mandl. Yet, slowly and strategically he shifted to a nationalist ideology, accommodating the anti-Semites who supported him in several elections. As Schorske points out, "Lueger reflected in his public positions in the fluid eighties the murky transition from democratic to protofascist politics."[87] Within two decades Lueger gained enormous political power and in 1896 he succeeded in

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[82] Sime, *Lise Meitner,* (1996), p. 14.
[83] Cercignani, *Ludwig Boltzmann,* (1998), p. 11.
[84] Sime, *Lise Meitner,* (1996), p. 9.
[85] Meitner, *Looking Back,* (1964), p. 2.
[86] Heindl, "Zur Entwicklung des Frauenstudiums in Österreich," (1990), p. 17.

becoming the mayor of the city of Vienna. Only a year later, in the parliamentary election of 1897, the Social Democrats, Lueger's severest critics, won fourteen seats for the first time. During his mayoralty and until his death in 1910, Lueger and his party had such a grip on Vienna that, as Geehr argues, "it became impossible to dislodge them until after World War I and the introduction of more equitable laws."[88] Feminists, Social Democrats, and the Jewish of Vienna faced the most strategically organized conservatism and anti-Semitism in the history of Vienna up to that point.[89] As Geehr skillfully demonstrates, "Lueger was an anti-Semite, not just a hater of individual Jews; his attitude implied long-term action against Jews and denial of equal rights."[90]

Besides his anti-Semitism, Lueger was deeply conservative, forcefully fighting against feminists and Social Democrats. During the election of 1901 a number of middle class feminists participated in Victor Adler's campaign. When the newspapers supporting the Christian Social Party reported this decision, they brutally insulted women by calling them prostitutes and whores.[91] The mayor reinforced and repeated the abuses. When two women dared to complain to Theodor Wähner, city councilor and editor of the *Deutsche Zeitung,* the paper most vigorously behind the Christian Socials, they were ridiculed and offended for a second time. In his usual demeaning manner, Lueger insulted Fickert personally during one of his speeches in a provincial diet session.[92] She was also forced to accept wage cuts and sharp reprimands from Viennese school authorities as a disciplinary measure for her radical ideas.[93]

Despite the political opposition and the tenacious resistance of the conservatives, at the turn of the century, feminists succeeded in gaining access to university studies and opened the way for younger women to obtain higher education and enter some of the professions.[94] The feminist movement was similar in a number

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[87] Schorske, *Fin-de-siècle Vienna,* (1980), p. 138.
[88] Geehr, *Karl Lueger,* (1990), p. 148.
[89] The reforms of 1848 improved the legal position of Jews in the Habsburg Empire. Jews could contemplate either a legal or a medical career and entered into banking and trading. With the crash of the Austrian stock exchange in 1873, Jews bankers found themselves accused of being responsible for the financial collapse. Serving as scapegoats, the Viennese Jews faced severe anti-Semitic propaganda. However, that was minimal compared to Lueger's later anti-Semitic campaigns (see Gay, *Freud: A Life for Our Time,* (1988), pp. 14-21; Okey, *The Habsburg Monarchy*, (2001)).
[90] Geehr, *Karl Lueger,* (1990), p. 16.
[91] Anderson, *Utopian Feminism,* (1992), p. 1.
[92] Geehr, *Karl Lueger,* (1990), p. 289.
[93] Anderson, "Feminism as a Vocation," (1990), p. 83.
[94] Not only conservatives, such as the Christian Socialists, were anti-feminists in *fin-de-siècle* Vienna. The radical intellectuals, such as the expressionist painter Oskar Kokoschka and the political critic Karl

of respects to the Social Democratic tradition. In addition of having practical goals, such as admission to university studies and access to professional posts, it aimed towards the self-improvement of women, their active participation in social and political life, and their cultural awareness. Such feminists as Fickert tried to transform middle and upper class women by a politics of pedagogy, just as the Social Democrats attempted to advance the social interests of the Austrian working class through *Bildung*. The feminist movement after all illustrates the nature of social changes that in *fin-de-siècle* Vienna led women to seek careers in science, in spite of the many limitations and difficulties they faced, such as restrictions on political participation.

Soon after their admission to the University of Vienna, the number of female students increased beyond expectations. In the first academic year, three women were registered as matriculated (*ordentliche*) and thirty-four as non-matriculated (*außerordentliche*) students.[95] Among these three was Elise Richter, later the first female doctoral student (*Dissertantin*) in the philosophical faculty.[96] Coming from a wealthy upper class family of the Viennese Jewish intelligentsia, Richter grew up in a disciplined but cultured environment. Her father was a medical doctor who assured her private education. Elise took the *Matura* as *Externistin* and studied Romance languages and literature. In 1907 she became the first *Dozentin* (lecturer) at the University of Vienna.

Richter's background is not exceptional among the women who chose to enroll in the university. The women who entered the University of Vienna and its surrounding institutes were mainly prosperous middle and upper class. The only school with official state recognition to prepare women for academic studies was the private *Gymansiale Mädchenschule* that the *Association for Extending Women's Education* founded in 1892. It was not until 1906 that the school was able to set up its own *Matura* exams; it changed its name to *Mädchen Obergymansium* (upper gymnasium for girls).[97] Receiving no subsidy from the Austrian government, the school depended on its wealthy pupils, most of them coming from the families of

Kraus, were influenced by the anti-feminist assumptions of their time as well. Kraus was often extremely polemic and critical of particular feminists and the movement in general (see Anderson, *Utopian Feminism,* (1992); Janik and Toulmin, *Wittgenstein's Vienna,* (1973), p. 69, 73-75). Also Carol Diethe has highlighted the antifeminist connotations in Kokoschka's work (see Diethe, *Aspects of Distorted Sexual Attitudes,* (1988); Cernuschi, *Re/casting Kokoschka* (2002)).

[95] Tuma, "Die Österreichischen Studentinnen der Universität Wien," (1990), p. 87.

[96] Andraschko, "Elise Richter," (1990), pp. 221-231.

[97] Anderson, *Utopian Feminism,* (1992), p. 31. Many of the women who later worked at the Institute for Radium Research attended the *Obergymnasium*.

businessmen, civil servants, and the Viennese upper class. Since Jews were among the leading economic force in Vienna, thirty-five to forty percent of the students were of Jewish descent. In the early days of the school, classes took place in the Natural History Museum. Despite the criticisms of radical feminists for its elitist character and despite the hostility of the educational authorities, the school soon flourished. One of the most important patrons of women's education was Marie von Najmajer, who in 1898, just a year after women's admission to the University, she set up an annual grant for full time university students of 150 florins.[98] In 1901 she donated 40,000 Kronen to support the school.[99]

During the academic year 1900/1, when women were already accepted to the medical faculty of the university, their numbers substantially increased. There were thirty-one matriculated students on the philosophical faculty and ten on the medical one, while the numbers of the non-matriculated students for the two faculties were eighty-seven and twenty-five respectively[100] (see table 2.1).

Table 2.1 Enrollment of female and male students at the University of Vienna, 1897-1914

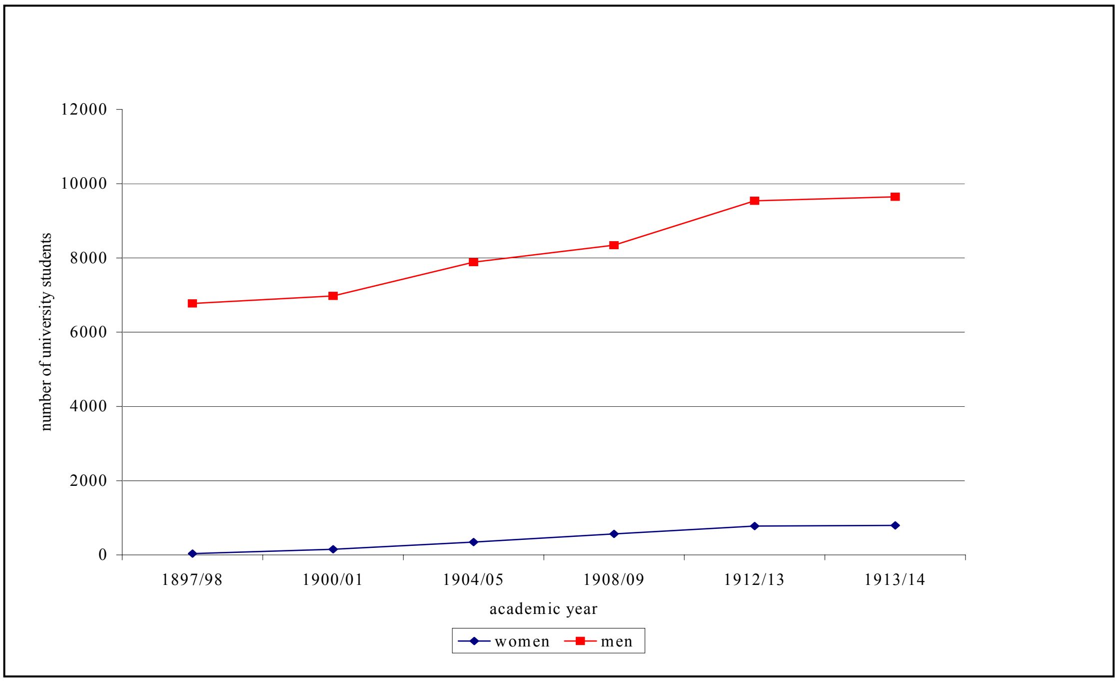
Acad. year	**Women (phil. faculty)**		**Women (med. faculty)**		**Women (all facul.)**	**Men (all facul.)**
	Matric.	**Non-matric.**	**Matric.**	**Non-matric.**		
1897/98	3	34	-	-	37	6775
1900/01	31	87	10	25	153	6975
1904/05	75	235	32	5	347	7886
1908/09	157	333	62	16	568	8340
1912/13	285	330	152	12	779	9535
1913/14	314	292	184	6	796	9645

During the academic year 1897/98, the ratio of women to men was 1:183.1; during the academic year just before the World War I there was one woman to 12.1

[98] Bandhauer-Schöffman, "Frauenbewegung und Studentinnen," (1990), p. 66. The amount of 150 florins was equivalent to the annual tuition to the *Gymansiale Mädchenschule.*
[99] Anderson, *Utopian Feminism,* (1992), p. 31.
[100] The figures in this table are based on Renate Tuma's work on Austrian women students in the University of Vienna (Tuma, "Die Österreichischen Studentinnen der Universität Wien," (1990), p. 80).

men. Within the first seventeen years of women's admission to the University of Vienna their number had multiplied 21.5 times (see chart 2.1).

Chart 2.1 Increase in the enrollment of female and male students at the University of Vienna, 1897-1914.[101]



Despite the steady increase of female students, their number in relation to the inhabitants of the city of Vienna was about 1:36,000 in 1913/14.[102] Considering the fact that the University was accessible only to the women of the Viennese elite who had the financial leisure to pursue their secondary education at the *Mädchenobergymnasium,* the above ratio is not surprizing. In 1900 the Ministry of Culture and Education, after conducting an inquiry about the need for a state *Gymnasium* for girls, rejected the feminists' request and established instead a *lycée*, a school preparing women for more "feminine" professional posts.[103]

What the above numbers indicate, nonetheless, is that the feminist movement and its members were not intellectual or political outsiders. They had an influence on women's choices, decisions, and lives. For instance, despite the modest beginnings of

[101] This chart includes both Austrian and international students.
[102] Tuma, "Die Österreichischen Studentinnen der Universität Wien," (1990), p. 81.
[103] Anderson, *Utopian Feminism,* (1992), pp. 31-32.

some feminist groups, the total membership of the *League* reached 40,000 women in 1914.[104] Whatever expressions were used and goals were anticipated, feminists and their supporters had forced a rearrangement of Viennese social institutions. Admission of women to the university was not the result of a natural process, but was engendered by the persistent efforts of the feminists. It clearly emerged out of a discourse that constructed a collective identity for upper and middle class Viennese women. By being able to attend university studies, women were also able to enter the cultural and physical space that surrounded the university building. Known as the *Mediziner-Viertel,*[105] the area around the University of Vienna serves as the midpoint for understanding how women assimilated themselves in the physics community and became part of it instead of invisible outsiders. It is there that women associated with their male colleagues, exchanged ideas, and acquired the *Bildung* that both feminists and Social Democrats aimed to and valued immensely.

2.7. Women Entering the Field of Physics

After their admission to the University of Vienna, women were welcomed to physics lectures and laboratory courses. Out of thirty-two Austrian women registered in the University of Vienna for the academic year 1897/98 ten took classes in physics.[106] In 1903 Olga Steindler (1897-1933) was the first to graduate with a major in physics. As a daughter of an attorney, Steindler studied at the private *Mädchengymnasium* of the *Association for Extended Women's Education* and took her exams as *Externistin* in Prague. In the fall semester of 1899/1900 she registered at the philosophical faculty and studied physics and mathematics. In her *Rigorosen*, the oral examination required for the degree, Exner and Boltzmann were her examiners.[107] Aware of women's need for emancipation, Steindler, while still a student, lectured at *Athenäum*. It was at the University of Vienna where Steindler met Felix Ehrenhaft, Exner's *Assisten* and part of his circle, whom she married in 1908. They were of the same age and shared a strong interest in physics, culture, and politics. Steindler devoted her career to women's *Bildung,* serving as director of

[104] Anderson, *Utopian Feminism,* (1992), pp. 90-91.
[105] Brinda-Konopik, "Robert Wilhelm Bunsen," (1992), p. 3.
[106] Tuma, "Die Oessterreichischen Studentinnen der Universitaet Wien," (1990), p. 87.
[107] Bischof, *Frauen am Wiener Institut,* (2000), p. 25.

Handelsakademie (Business Academy), becoming one of the first women school directors.

The same enthusiasm for physics brought a second woman, Lise Meitner, to the Physics Institute at Türkenstrasse. She graduated in 1906, the same year as Selma Freud. The latter did not pursue any further work in the field. Meitner and Freud shared a work room in the institute at Türkenstrasse.[108] After her graduation Meitner stayed one more year at the Institute and worked with Stefan Meyer on radioactivity research in a room next to Przibram's. In a well-documented biography, Ruth Sime highlights the meaning of the ethos and collegiality of Exner's circle in Meitner's career.

> One of Lise's fellow students, Karl Przibram, remembered Exner for his contagious enthusiasm and for the community spirit that went far beyond the usual relationship between teacher and students. This sense of community was essential for Lise in finding her way. She had come to the university on her own, very conscious of how few women there were and how visible she was, how some of the men went out of their way to be pleasant and others, just as conspicuously, did the opposite.[109]

Slowly and persistently, despite those who conspicuously blocked their way, women were engaging with the physics community. Apparently, they were not only accepted in lectures but they were also assigned work space within physics laboratories, as Freud's and Meitner's trajectory illustrates. Marking the transition from exclusion to integration in *fin-de-siècle* Vienna, women gained access to the University of Vienna and to almost all of the scientific institutes in the *Mediziner-Viertel.* As table 2.2 illustrates, from the fall semester of 1897/98 to the spring semester of 1913/14, women were actively interested in traditionally male dominated fields.[110]

[108] Przibram, "Errinerungen," (1959), p. 3.
[109] Sime, *Lise Meitner,* (1996), p. 12.
[110] Tuma, "Die Osterreichischen Studentinnen" (1990), p. 87.

Table 2.2 Number of women enrolled in courses in the philosophical faculty of the University of Vienna by field.

Fields	1897/98	1904/05	1908/09	1913/14
Philosophy	26	178	329	404
Psychology	17	123	244	204
German Philology	18	186	322	305
Pedagogy	13	172	310	323
History	15	86	141	157
History of Art	6	70	135	156
Physics	10	72	116	145
Chemistry	9	70	108	133
Mathematics	12	55	97	128
Total [111]	32	218	400	520

During the first academic year, 31.3% of the total number of the enrolled female students chose the field of physics. In chemistry the percentage was 28.1 and in mathematics was 37.5 for the same year. After all, these percentages were impressingly close to 40.6% for pedagogy and not far off from 56.3% of philology, fields conventionally characterized as female ones.

2.8. The *Mediziner-Viertel* as an *in vivo* Cultural and Epistemic Laboratory

The area around the university was set up as a cultural and epistemic center. It served as an *in vivo* laboratory of the Viennese science, feminist politics, and upper and middle class culture. The triangle stretching behind the University of Vienna, first known as the *Universitätsviertel,* was designed on the political ideal for a humanistic education and a liberal culture. The face of Vienna was transformed through the reconstruction of the Ring, the area surrounding the inner city of the baroque palaces

[111] The total refers to the actual number of women enrolled at the philosophical faculty of the University of Vienna. Those were able to attend several courses in different fields. This is why the total does not match the numbers given by field.

and churches. The Ringstrasse, “a visual expression of the values of a social class,”[112] as Schorske puts it, was dominated by the centers of higher culture such as the *Opera* and the *Burgtheater*, of constitutional government such as the *Rathaus* and the *Parliament,* and finally the University, a symbol of liberal learning. The area behind the University, including the general hospital, was intended to nurture liberal ideals and to promote culture and science.

By the end of the 19th century the image of the *Viertel* shifted dramatically. The *Zinhausen*, several story buildings designed as apartments and offered as a solution to the significant housing shortage in the city, originally dominated the district around the University. Built to house the working class, they usually contained sixteen units and were absolutely inferior to the *Adelspalais*, the aristocratic palaces they were trying to mimic architecturally.[113] The Institute in Türkenstrasse was one of the *Zinshausen*, a “provisional” solution to a pressing need for an institute closer to the medical institutes and the university.[114] By the turn of the century the face of the city’s ninth district changed radically by the number of scientific institutes that were founded and the new culture they established.

The prestige of the Viennese physicians quickly dominated the *Viertel.* They turned it into a *Mediziner-Viertel,* a designation that slowly replaced its previous name. The grouping of the medical institutes in the *Viertel* enforced a sense of community and disciplinary cohesion.[115] In the meantime, by acquiring its own professional space within the *Viertel,* the community of natural scientists strengthened their ties. Besides the Chemistry and Physics Institutes, the Mathematics Institute was at Strudelhofgasse 5, a side street that crossed Währingerstrasse passing the *Josephinum*. This unique concentration of science buildings mattered seriously to the science produced and the scientists involved in its production.[116] On the one hand,

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[112] Schorske, *Fin-de-siècle Vienna,* (1980), p. 25.
[113] Schorske, *Fin-de-siècle Vienna,* (1980), p. 47.
[114] Przibram, “Errinerungen,” (1959), p. 1.
[115] As early as 1920 Viennese physicians, with their long disciplinary tradition and international prestige, were the first to establish an institute devoted to the history of their discipline and preserving the fame of their field. The Institute for the History of Medicine was founded by Max Neuburger, a full professor for the history of Medicine at the University of Vienna. Neuburger moved a valuable collection of pictures, specimens, instruments, and archival material to the *Josephinum* (Wyklicky, “Das Institut für Geschichte der Medizin,”(1990), p. 1).
[116] Interestingly enough the building at Türkenstrasse also housed the Institute for the History of Music on the ground floor with Guido Adler as its director (Przibram, “Errinerungen,” (1959), p. 1). The *Kunsthistorische Apparat*, the predecessor of the first Institute for the History of Art, was housed at the corner of Universitätstrasse and Reichsratstrasse(see Institut für Kunstgeschichte, Universität Wien, http://www.univie.ac.at/kunstgeschichte-institut last checked on 2/20/2003). The *Mediziner-Viertel* was

physicists and chemists were able to transfer their expertise to the medical faculty by educating young physicians and pharmacists. Many of the medical students took courses in experimental physics and organic and inorganic chemistry, crossing Währingerstrasse several times a day moving from one lecture hall to the other. Professors and students intermingled not only in the classrooms but also in the traditional Viennese coffee shops of the district where scientific discussions were carried on. On the other hand, instruments, experimental apparatuses, and theoretical ideas of different scientific disciplines crossed Währingerstrasse the same way that scientists crossed their institutional boundaries. Physicists worked with the chemists next door. Physical chemistry acquired its own institute, challenging the traditional unity of classical chemistry. Boltzmann, although a physicist, was offered a position in mathematics, an offer that the philosophical faculty justified by arguing that his research was also “excellent as mathematical works, containing solutions of very difficult problems of analytical mechanics and especially of probability calculus.”[117]

For all its fruitfulness, the intermingling of natural scientists and physicians in their professional space explains one aspect of the *Mediziner-Viertle’s* idiosyncratic function as an epistemic *in vivo* laboratory. In a sense, the *Viertel* also occupied a cultural midpoint in the everyday lives of its scientists. When Ferstel designed the University his task was not only to accommodate the faculties, lecture halls, and administrative facilities but also to provide living quarters for the leading professors.[118] In the plans of the Chemistry Institute, Ferstel elegantly merged an Italian Renaissance style with the German architectural tradition to combine scientific work with residences under the same roof. His layouts of the Physics Institute, although never realized, were characterized by the same architectural peculiarity. Even in the primitive Physics Institute at Türkenstrasse the directors reserved residential apartments for themselves and their families.[119] The case of Boltzmann’s apartment, which was integrated into the *II. Physicalisches Institut* directed by Exner during the restructuring of the Institutes in 1902, is an indicative example. Directors lived and worked under the same roof, transforming the laboratory from a strictly sterilized and professional space to a vivid dwelling.

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the professional space not only of natural scientists and physicians but also historians, artists, and musicians.

117 Cercignani, *Ludwig Boltzmann,* (1998), p. 10.

118 Plassmeyer, “Nineteenth Century Architecture,” (1999), p. 192.

119 Cercignani, *Ludwig Boltzmann,* (1998), p. 15.

To connect space with dwelling is to emphasize that space is a process and not a mere location. The *Mediziner-Viertel* acquired its being not by bringing several buildings together in a specific location but by transforming them to vivid cells of a cultural and epistemic process. As Heidegger argues, "A space is something that has been made room for, something that-namely within a boundary, Greek *peras*. A boundary is not that at which something stops but, as the Greeks recognized, the boundary is that from which something *begins its presencing*. That is why the concept is that of *horismos*, that is horizon, the boundary."[120] Thus the *Viertel,* a space functioning as an *in vivo* laboratory was let into its bounds, was actually creating a space by crossing and pushing the epistemic and cultural boundaries of *fin-de-siècle* Vienna.

It was not by chance that Sigmund Freud, whose views on human sexuality crossed the boundaries of upper-class Viennese sensibilities, chose an apartment building within the bounds of the *Viertel* as his dwelling.[121] From 1873 to 1885, Freud studied at the University of Vienna, lived his passion for physiology and neurology, and after graduation took a lower post at the general hospital.[122] In late summer of 1891, Freud chose to move into a spacious apartment at Berggasse 19, a side street parallel to Türkenstrasse.[123] His works on hysteria, the interpretation of dreams and the psychopathology of every day life found a wide audience among the upper-class, especially Viennese women. After he was appointed as an associate professor at the University of Vienna, his apartment on Bergasse became the meeting place for four physicians. Every Wednesday the group discussed psychoanalytic issues and soon evolved to the Vienna Psychoanalytic Society, with more than a dozen participants by 1908. Freud moved his office to Berggasse 35.

As highly populated residential area, the *Viertel* hosted a number of other prominent scientists and intellectuals.[124] The designer and architect of the *Universitätsviertel,* Ferstel, could not have chosen a different area for his own

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[120] Heidegger, "Building Dwelling Thinking," (1971), p. 154.
[121] Viktor Adler, the founder of the Social Democratic Party used the same apartment as his residence between 1881 and 1889 (Janik and Veigl, *Wittgenstein in Vienna,* (1998), p. 21)
[122] Gay, "Sigmund Freud: A Brief Life," (1989), p. xi-xxix.
[123] Janik and Veigl, *Wittgenstein in Vienna,* (1998), p. 19.
[124] The physicist Hans Thirring, lived on Strudelhofgasse 13, close to the Mathematics Institute Reiter, "Vienna: A Random Walk in Science," (2001), p. 482.

residence. In 1881 he moved to the *Haus Hollitzer,* an apartment building of his design behind the Votivkirche.[125]

2.9. Setting the Scene for the Emergence of Radioactivity

I propose to read the history of radioactivity in early 20th century Vienna as a chapter in the urban reconstruction of the city, the creation of the *Mediziner-Viertel,* and the architectural grouping of diverse laboratories. The physicists of *fin-de-siècle* Vienna were strongly attached to the locality of their institute and the culture that surrounded it. Their face-to-face interaction with chemists, physiologists, anatomists, and pharmacists, created a scientific network enmeshed in the cultural life of the city. The coffeehouses of the area provided the physicists with a space for social interaction where endless discussions on science enforced feelings of collegiality. Paradoxically, by retaining the scientific discourse outside the laboratory and working in a shabby building, the Viennese physicists experienced lack of disciplinary professionalism and prestige. This is the scene where the Radium Institute was established in 1910.

At the same time feminist ideology and shifts in political power enforced distinct lived experiences for women and men in the Viennese society. Decisive appointments at the higher positions of the Physics Institutes such as those of Lang, Boltzmann, and Exner brought about not only intellectual transitions in the culture of physics but also transitions in the gender assumptions of the physics community. Stressing partnership and collegiality, the “Exner circle” welcomed women in classrooms and laboratory courses, and also as doctoral students. Przibram’s recollections reveal a unique pattern of gendered politics of collaboration with women shaping their own space in the physics laboratory.

Emphasizing the importance of the *Mediziner-Viertel* in the cultural and scientific scene of *fin-de-siècle* Vienna, I intend to highlight collaborations and the politics that brought them into existence. Instead of speaking about women’s segregation from this extraordinary milieu, I choose to focus on the ways they were actually integrated into the culture of Viennese radiophysics. In the years after the

[125] Ferstel’s daughter in law, Marie Ferstel, was a close friend of Freud one of those who helped him to acquire the title of professor at the University of Vienna (Janik and Veigl, *Wittgenstein in Vienna* (1998), pp. 20, 193).

turn of the century, by the time there was a need for a specialized institute in radioactivity, the *Mediziner-Viertel* was in its maturity. Radium became a new vehicle by means of which boundaries were crossed and disciplines transformed within the *Viertel*. It also became a vehicle by which women entered into the emerging field of radioactivity.

CHAPTER 3
RADIUM AS A BOUNDARY OBJECT: THE ESTABLISHMENT OF THE INSTITUTE FOR RADIUM RESEARCH

Susan Leigh Star and James Griesemer, examining the development of the Museum of Vertebrate Zoology at the University of California during its early years, coined the term 'boundary object.'[1] Focused on the early history of a natural museum, Star and Griesemer analyze the ways in which amateurs, professionals, trappers, and administrators who surrounded the museum made sense of their different viewpoints. Objects of their common interest, such as fossils, species and subspecies of mammals and birds, field notes, and maps inhabit multiple worlds, simultaneously satisfying the informational requirements of each of them. All these are boundary objects, "objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites."[2] The different social worlds involved maintain their autonomy, but at the same time participants develop flexible economies of information that ensure trade across those world boundaries. After all despite its heterogeneity, scientific work proves also to be a process of cooperation.

The same metaphor of trade becomes central to the way Peter Galison analyzes the history of the 20th century physics. Examining what makes physics—"this complicated patchwork of highly structured pieces"—stand as a well-functioning unity, Galison suggests a picture of the discipline divided into *subcultures*: theoretical, experimental, and that of instruments making. The term 'trading zone' based upon the anthropological metaphor of the trade between the peasants and the landowning classes in the southern Cauco in Colombia, models Galison's argument about the quasi-autonomy of these subcultures. According to this model, trade can take place even when the significance of the objects traded is different for the two traders. A new language emerges in order to serve the needs for communication among the different groups. Galison illustrates his point by making

[1] Star and Griesemer, "Institutional Ecology," (1989), pp. 387-420. On boundary objects see also Star, "The Structure of Ill-Structured Solutions," (1989), pp. 37-54; Bowker and Star, *Sorting Things Out,* (1999), pp.286-98.
[2] Star and Griesemer, " Institutional Ecology," (1989), p. 411.

use of a linguistic mechanism—the function of Creole as interlanguage between trading groups. Most of all, "What is crucial is that in the local context of the trading zone, despite the differences in classification, significance, and standards of demonstration, the two groups can collaborate."[3]

Abstracting from the richness of these two theoretical approaches, I focus only on their main concepts, that of 'trading zone' and 'boundary object.' I employ the concept of 'boundary object' to describe the multiple identities of radium, a boundary object shared by several subdisciplines, scientific cultures, industrialists, instrument makers, and medical technicians. Since its discovery in 1898, radium was shared between chemists and physicists. Industrialists, miners, and academics soon added their own perspectives on the new element. Different social worlds were forced into international cooperation and managed to level out differences in scientific styles, to overcome difficulties in financial exchanges, and to smooth over their diverse administrative manners. French, Austrians, and Anglo-Saxons not only traded radium and methods of research but also created an international committee in order to standardize their boundary object. The *International Radium Standards Committee* was founded in September 1910 during the second International Congress on Radiology and Electricity in Brussels, aiming to define a unit for radioactivity and to arrange the preparation of a radium standard.[4] By the end of October of the same year Austrians, realizing the multiple potentials of research on radium, established in Vienna the Institute for Radium Research, the first specialized center on radioactivity.[5] A trading zone between physics and chemistry, unavoidably radioactivity engaged a number of other disciplines and scientific cultures in its development.

During the first decade of the Institute's activity a considerable number of women entered the field, taking advantage of the multiple points of entrance that the trading zone of radioactivity offered them. They carried their knowledge and expertise within the boundaries of the *Mediziner-Viertel,* moving from one institute to another. Professionally, women fashioned themselves as experimenters and not as support laboratory staff at the Radium Institute. Common gender assumptions about women's

[3] Galison, *Image and Logic*, (1997), p. 803.
[4] Badash, *Radioactivity in America,* (1979), pp. 256-7.
[5] Hittner, *Geschichte des Studienfaches,* (1949), p. 72.

participation in science fail to account for such an exceptional role. As Marelene and Geoffrey Rayner-Canham argue, the "field was exciting and new, and hence appealing to these ebullient women who were looking for a purpose in life."[6] The Viennese women, having their own professional agenda, were very specifically looking for a research position in one of Vienna's laboratories instead of a "purpose in life." Arguing that the interdisciplinary character of radioactivity facilitated the entrance of women in the Institute in the late 1910s, I want here to trace the emergence of the field.

3.1. The Biography of a Boundary Object:
a. Between Physicists and Chemists

Radium was discovered in France at the end of the 19th century but it was strongly linked to Röntgen's discovery of x-rays in his laboratory in Würzburg, Germany. In late 1895 Röntgen announced that the passage of an electric discharge from an induction coil through a partially evacuated glass tube produces what he called x-rays. The emitted radiation was able to penetrate not only the black paper Röntgen used in his original experiment but thick material objects as well. In January 1896 Henri Poincaré presented Röntgen's discovery to the French Academy of Sciences posing the question whether any naturally fluorescent or phosphorescent substance could emit penetrating radiation similar to that of x-rays.[7] To Antoine-Henri Bequerel's satisfaction, that proved to be possible in the case of uranium.[8]

The same year, Bequerel observed the darkening of a photographic plate in contact with uranium crystals and described the invisible radiation emitted by uranium. In March 1896, during a Monday meeting of the French Academy of Sciences, Bequerel presented his findings, which were then published within ten days.[9] Shortly afterwards, based on intensive experimentation, Bequerel concluded

6 Rayner-Canham, M and Rayner-Canham, G., *Harriet Brooks,* (1992), p. 106.
7 Kohl, "Von den 'Bequerel-Strahlen'," (1997), p. 489.
8 Dutreix and Dutreix, "Henri Bequerel," (1995), p. 1870.
9 Bequerel "Sur les Radiations Invisible," (1896), pp. 501-3.

that the emissions were not related to visible fluorescence but to a specific property of uranium.[10]

At the time Marie Curie was working on her doctoral thesis under Bequerel's supervision.[11] She conducted her research on the rue l' Homond at the *Ecole Municipale de physique et de chimie industrielles* [EPCI], in a damp storehouse turned into a physics laboratory. *Le hanger* (the shed), as the laboratory was known, was directed by her husband, Pierre Curie.[12] Although modest and short of apparatus, it provided Marie with enough space to perform her experiments. After the discovery of the new radiation Marie Curie decided to work on Bequerel rays or uranium rays as they were called at the time. Her aim was to investigate the properties of uranium radiation and a necessary first step was to develop an accurate and reliable method of measuring radiation. The two brothers, Pierre and Paul-Jacques Curie, both prominent physicists working on piezoelectricity and physics of crystals, provided the necessary apparatus.[13]

A method based on photographic plates was unassailable for demonstrating the existence of the new radiation but insufficient for measuring its intensity. The density of the exposure on the film, though, could be used as a crude measure of the intensity of the radiation, but was not accurate enough. At the same time the ionizing property of the radiation had already been used for the case of x-rays to measure their intensity. Nonetheless, instruments such as the gold leaf electroscope and the spinthariscope designed by William Crookes, despite their wide usage, were not accurate and precise enough to be employed for the measurement of uranium rays.[14] The need for new instrumentation became more pressing with the discovery of the new radiation. Pierre and Paul-Jacques Curie had already devised an electrometer in the early 1880s based on the piezoelectric effect of quartz crystal. That apparatus measured small quantities of electricity in absolute terms.

In the light of the new and slowly emerging field of radiation physics, Marie employed the Curie electrometer in her research, equipped it with an ionization

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[10] For more on Bequerel's experiments see: Kohl, "Von den 'Bequerel-Strahlen'," (1997), pp. 488-491; Peh, "The Discovery of Radioactivity," (1996), pp. 627-630. Blaufox, "Becquerel," (1996), pp. 145-154; Dutreix and Dutreix, "Henri Bequerel," (1995), pp. 1869-1875.
[11] Mould, "The Discovery of Radium," (1998), p. 1234.
[12] Mould, "The Discovery of Radium," (1998), p. 1237; Peh, "The Discovery of Radioactivity," (1996), p. 628.
[13] Mould, "The Discovery of Radium," (1998), p. 1236-38.

chamber, and transformed it into a reliable tool for ionization measurements. Carrying an electrometer from crystal to radiation physics, Marie demonstrated that the intensity of the radiation was proportional to the amount of uranium. The new method proved to be superior to the photographic plate method. As Marie conducted research on a number of other substances, she soon discovered that only thorium possessed properties similar to those of uranium. Her hypothesis was that radiation was an atomic property unrelated to its chemical structure. Additionally, pitchblende, raw ore containing uranium, was more radioactive than the amounts of included uranium could explain. Thus, she soon concluded that there had to be a new radioactive element in the pitchblende. Her experiments with synthetic chalcolite supported her hypothesis and prompted Pierre Curie to involve himself fully in the study of radioactive substances.[15]

Both of them had come to the problem through physics and had been clearly trained and integrated in that culture. Pierre worked on crystal physics and Marie had been working on the magnetic properties of various minerals under the supervision of physicist Gabriel Lippmann.[16] Intensely and deeply devoted to research, Pierre concentrated on the study of the physical properties of the radiation while Marie performed the radiochemical analyses. Between the two, Marie crossed the boundary of her discipline by using methods from chemistry to analyze pitchblende samples while Pierre kept his identity as a physicist rigid. As Davis argues, "If he [Pierre] tended to concentrate on the physics aspect of the work of radioactivity and she on chemistry, this would seem to have been a matter of personal preference."[17] I argue that it was more than a simple preference. As Pycior documents, Marie started to work on radioactivity in December 1897. It was not before late March 1898 that Pierre joined her.[18] Forced by the subject of her research, by the time Pierre got involved, Marie had already integrated chemical methods in the study of the new substances. Her experiments with synthetic chalcolite and the study of all chemical compounds of uranium and thorium occurred in this early period. Thus, the core of

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[14] Mould, "The Discovery of Radium," (1998), p. 1236.
[15] Mould, "The Discovery of Radium," (1998), p. 1238.
[16] Mould, "The Discovery of Radium," (1998), p. 1233; Pycior, "Marie Curie," (1997), pp. 31-50.
[17] Davis, "The Research School of Marie Curie," (1995), p. 323
[18] Pycior, "Reaping the Benefits," (1993) p. 304.

her own research program required her to continue working on the isolation of new elements.[19]

In July 1898, after using a combination of electrometric methods and chemical analyses, the Curies discovered polonium. Since they were not members of the French Academy of Sciences, they were not allowed to present their results in the weekly meetings of the academicians. It was Bequerel who presented the discovery on their behalf on July 18.[20]

As became obvious, the emergence of the Curies' new research challenged the unity of traditional chemistry. French chemists soon became uneasy and academicians uncomfortable, feeling that they might lose control over their discipline. To chemists, outsiders like the Curies seemed to be encroaching on their resources and disrupting disciplinary boundaries. None of the first researchers was a chemist. Marie had primarily studied physics, receiving the *Diplôme de Licencié ès Sciences physiques* (1893), and a year later received a *licencié* in mathematics as well.[21] Pierre had received his *licencié* in physics from the *Sorbonne* in 1877 and in the early 1880s, collaborating with his brother, discovered the phenomenon of piezoelectrcity. At the time of their early research on radioactivity both were working in a physics laboratory training engineers and "recruiting students from the *écoles primaires supérieures.*"[22] Bequerel, who come from a family with strong tradition of working in physics, attended the *Ecole Polytechnique* in 1873. Two years later he was first appointed as a Demonstrator at the *Polytechnique* and then Professor of Physics in 1895. That year was significant for him since he was also appointed as a Professor of Physics at the Museum of Natural History, a position already held by two previous generations of Bequerels. In 1889 Henri was elected to the Academy of Science in recognition of his work in physics. [23]

It was probably because of Bequerel's membership in the Academy that French chemist did not overreact. They simply insisted that before the new element could be given any official status, it had to be successfully isolated, its atomic weight

[19] See the appendix for the historical names of the new radioactive elements.
[20] Mould, "The Discovery of Radium," (1998) p. 1238; Mazeron and Gerbaulet, "The Centenary of Discovery of Radium," (1998), p. 207. The original publication of the Curies' discovery appeared in *Comptes Rendus,* "Sur une substance nouvelle radioactive," (1898), pp. 175-78.
[21] Mould, "The Discovery of Radium," (1998), p. 1233.
[22] Davis, "The Research School of Marie Curie," (1995), p. 324.
[23] Blaufox, "Bequerel," (1996), p. 145

had to be measured, and its spectroscopic characteristics analyzed.[24] The chemist Gustave Bémont, Pierre's close collaborator and director of the chemistry laboratory next door in EPCI, joined the team and in the meantime the spectroscopist Eugéne Demarçay was also enlisted as a collaborator. Gustave Bémont offered his expertise on the tedious chemical analysis. Intense measurements and studies of the properties of radiation led the Curies in December 1898 to the discovery of a second element, the one they named 'radium.' Bequerel was once again their representative in the Academy. Shortly after, a joint publication by the Curies and Bemont appeared in *Comptes Rendus,* announcing the discovery.[25] It is no coincidence that the publication immediately following that one was Demarçay's "Sur la Spectre d'une Substance Radioactive" (On the Spectrum of a Radioactive Substance), where he analyzed the spectrum of radium.[26] Marie coined the term radioactivity[27] to name the research in radiation physics rejecting the term "hyper-phosphorescence," used by J.J. Thomson in England, as misleading for the nature of the new radiation.[28] A Nobel Prize in physics, awarded jointly to the Curies and Bequerel in 1903, legitimated the importance of the new emerging field.

In the years that followed its discovery, radium lived in both worlds: that of physics and chemistry. In the French scene the chemist André Debierne, the *chef-de-travaux* at Marie's laboratory after Pierre's death in 1906, suggested a number of chemical techniques and facilitated the work of physicists employed in the lab. A number of young researchers flooded Curie's laboratory working on the chemistry of the new science.[29] The Nobel Prize, awarded to Marie Curie in 1911, this time in chemistry, gives us a glimpse of the different domains engaged in research on radium. Yet, in the early days of its discovery, besides addressing radium as an object shared

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[24] For the reaction of the French chemists see Peh, "The Discovery of Radioactivity and Radium," (1996), p. 628.
[25] Curie, M. and P. and Bemont, "Sur une nouvelle substance," (1898), pp. 1274-5. See also Peh, "The Discovery of Radioactivity," (1996), p. 627-28.
[26] Mould, "The Discovery of Radium," (1998), p. 1238.
[27] Pycior, "Reaping the Benefits," (1993), p. 305
[28] Davis, "The Research School of Marie Curie," (1995), p. 328.
[29] In the Anglo-American scene the situation was similar to the one in France. As Lawrence Badash describes, because some of the experiments required chemical separations of radioelements, the physicist Ernest Rutherford "secured the services of a young demonstrator in the chemistry department, named Frederick Soddy." At the time Rutherford was still at McGill in Canada. (Badash, *Radioactivity in America*, (1979) p. 15).

between chemists and physicists, Austrian industrialists added one more vision, that of radium as potential source of financial benefit.

b. Among Industrialists, Government Administrators, and Science Practitioners in Austria

From the discovery of polonium in July 1898 to that of radium in December the same year, it took the Curies a little more than five months to overcome the academicians' concerns, a process that forced them to enlist a chemist and a spectroscopist into their team. As the French Academy insisted on the isolation and spectroscopic corroboration of polonium, the Curies needed to process enormous amounts of uranium pitchblende in order to extract a few milligrams of polonium. The only available uranium mine was the one in St. Joachimstal, Bohemia, then part of the Austro-Hungarian Empire. The mines had a monopoly on the uranium used in industry to color the famous Bohemian glass and porcelain.[30] Since the Curies did research in their old, miserable laboratory with insufficient funds and apparatus, they had no chance of approaching the mines directly to ask for a donation of pitchblende. To enlist the support of uranium producers, they had to choose an indirect way and address those who spoke their parlance. The place to turn to was more or less evident: Pierre and Marie wrote directly to the *Kaiserliche Akademie der Wissenschaften* (today the Austrian Academy of Sciences), asking the Austrian academicians to help them obtain 30 to 100 kilos of residue from the Bohemian mines. "The purpose of this research is exclusively scientific," they emphasized, and thus the Academy "would arrange that the administration of the Joachimstal facilitate our research."[31]

The Austrians had already acquired a reputation as scrupulous and progressive front-line experimenters since the discovery of x-rays. Immediately after Röntgen observed the effect of the new rays and presented his findings to the Würzburg Physical-Medical Society, he sent copies of the report, together with x-ray photographs, to several scientists in Europe. Among them, Exner received the material on January 4, 1896, including nine x-ray pictures.[32] Amazed by the new

[30] Kaiserliche Academie der Wissenschaften in Wien, Konzepte, no. 20 015, AÖAW.
[31] The Curies to the Austrian Academy, 1898, no. 25 081, AÖAW, (translation mine).
[32] Karlik and Schmid, *Franz Serafin Exner,* (1982), p. 85.

phenomenon and persuaded by the power of the unexpected images, portraying inner parts of human bodies, Exner immediately reported the discovery to his colleagues and prompted his advisee Eduard Haschek to work on this topic. Three days later he reported the event to the Chemical-Physical Society and his brother, the physiologist Sigmund Exner, broke the news to the Society of Physicians.[33] Ernst Lecher, a young assistant professor from Prague, attended Exner's presentation. Immediately afterwards Lecher published a report in the *Wiener Presse,* the editor of which happened to be his father.[34] *Die Presse* and the rest of the Viennese press devoted long articles to the discovery, including x-ray photographs. Around the end of 1896 Sigmund Exner, deeply impressed by the use of x-rays in medicine and physiology, presented an apparatus for the localization of infected areas to the Viennese Society of Physicians.[35] Within the next months the Viennese clinics anticipated the use of x-rays for medical purposes and various physicians began to use them as a diagnostic tool and to treat skin diseases, tumors, and leukemia.[36]

Thus, the Curies had good reason to seek the assistance of their Austrian colleagues in acquiring the pitchblende for their research. They were not wrong. Eduard Suess, the director of the Academy, sent Pierre a telegram assuring him that the mines would provide uranium-ore residues for free.[37] In his reply on November 19, 1898, Pierre praised "the liberal spirit of Suess's government."[38] A month later the Curies discovered radium, and as an appreciation of Austrian's help they sent an enriched radium sample, a valuable gift, to the Vienna Academy.[39]

While French physicists and chemists focused intensely on radium research, Austrian scientists did not want to play the role of mere providers of radium for their French colleagues. Their concerns were scientific as well. The physicist Stefan Meyer, a student of Franz Exner, had already expressed a strong interest in probing

[33] Karlik and Schmid, *Franz Serafin Exner*, (1982), p. 85; Fischer, *Geschichte der Gesellschaft der Ärzte,* (1938), p. 155.
[34] Julian, "The early Days of the X-Ray Revolution," (1996), p. 39.
[35] Fischer, *Geschichte der Gesellschaft der Ärzte*, (1938), p. 155.
[36] Karlik and Schmid, *Franz Serafin Exner*, (1982), p. 86; Alth, *50 Jahre Strahlentherapie Lainz*, (1981), p. 4; Kogelnik, "The History and Evolution of Radiotherapy," (1996), p. 221.
[37] As Pierre Curie received Suess's telegram via Michel Levy (Pierre Curie to Suess, November 17, 1898, AÖAW). Between 1898 and 1899 the Curies received 1.1 tons of pitchblende from the Austrians. By 1906 the amount went up to 23.6 tons (Reiter, "Stefan Meyer" (2001), p. 110). The first amount was supplied at no cost and the ones followed were sold for especially low prices (Kaiserliche Academie der Wissenschaften in Wien, Konzepte, no. 20 015, AÖAW).
[38] Pierre Curie to Suess, November 17, 1898, AÖAW.
[39] Meyer, "Die Vorgeschichte," (1950), p. 1.

radium. The year of its discovery, Meyer acquired a small sample of radium from Fiedrich Otto Giesel, a chemist involved in radioactivity research in Germany with which he hoped to measure the magnetic permeability of radium.[40] According to Meyer's assumption, magnetic permeability depended upon the atomic weight of the elements.[41] Combining the skills of a physicist and a chemist, Meyer extended his research to some 200 inorganic compounds of all the known elements including radium and polonium.[42] Soon Meyer teamed up with the physicist Egon von Schweidler, in order to conduct experiments on the magnetic properties of the radiation of radium and polonium. Those experiments led them to the discovery of the magnetic deflection of the "Becquerel rays," what become known as beta rays, emitted by radium. They were also able to distinguish them from those emitted by polonium (alpha rays).[43]

Given the interest of the Viennese physicists to radium research, in 1901, Suess, together with members of the mathematical and natural sciences division (mathematisch-naturwissenschaften Klasse) of the Academy, prompted by Exner, decided to set up a commission for "the intensive study of the radioactive substances."[44] The Academy agreed with the Ministry of Agriculture to purchase the necessary raw material from the mines in St. Joachimstal. The Physics Institute at Türkenstrasse, proved to be insufficient for carrying research on radium. The inadequate equipment was not the only obstacle. Theoretically, out of 23,000 kg residue, only 12 grams of radium could be extracted.[45] Such gigantic amounts of pitchblende required plenty of space, experienced chemists, and the facilities of an industrial-like laboratory.[46] The small makeshift Institute was not designed for such

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[40] Reiter, "Stefan Meyer," (2001), pp. 109-10; Meyer, "Die Vorgeschichte," (1950), p. 1.
[41] Meyer, "Magnetic Properties of the Elements," (1899), pp. 325-334.
[42] Meyer, "Magnetic Properties of Inorganic Compounts," (1899), p. 236-263. Meyer had studied physics and chemistry at the University of Vienna and was able to combine both in his early research on radioactivity (Karlik and Schmid, *Franz Serafin Exner,* (1982), p. 107).
[43] Reiter, "Stefan Meyer," (2001), pp. 109-10.
[44] Suess and Lang to Auer von Welsbach, July 10, 1901, AÖAW.
[45] Meyer, "Die Vorgeschichte," (1950), p. 10.
[46] The French for example carried out the purification of the raw material in the Central Company for Chemistry Production (*Société Central de Produits Chimiques*) a spacious factory where the chemist André Debierne could handle the enormous amounts of pitchblende. Only after the first extraction further work was done at Curie's laboratory. (Boudia, "The Curie Laboratory," (1997), p. 250); Mazeron and Gerbaulet, "The Centenary of Discovery" (1998), p. 207). As Soraya Boudia points out, Debierne "had to adapt laboratory techniques and perfect industrial treatment methods." (Boudia, "The Curie Laboratory" (1997), pp. 250-51.) The company provided chemical products and the staff salaries. On return they obtained a share of the extracted radium salts for marketing. The forced

research. It was Karl Auer von Welsbach who eventually offered to the commission the appropriate space.

Auer von Welsbach owned an affluent gas-lamp industry located in Atzgersdorf near Vienna. He had studied chemistry and physics at the Technical University of Vienna, worked at the University of Heidelberg as a lecturer on inorganic chemistry, and later as *Assistent* at the second Chemistry Institute in Vienna. His patent for a new method to produce incandescent mantle out of 99% thorium oxide, boosted Auer von Welsbach's company to become the supplier for a new, worldwide industry.[47] For the new patent, Auer von Welsbach benefited from the research on radioactive elements at the Physics Institute. At the time, Ludwig Haitinger was the gas-lamp industry's manager. As a chemist, Haitinger had attended lectures and laboratory courses at the Chemistry Institute and was acquainted with the physicists of the neighboring institute.[48] Before he accepted the position of the industry's manager, Haitinger conducted research on uranium, rare-earth elements, and the technical improvement of the gas lamp at the Chemistry Institute. Thus, binding together the scientific and industrial culture with expertise in chemistry, both Auer von Welsbach and Haitinger appealed to Exner and the Austrian Academy as the right persons in the perfect position. Auer von Welsbach owned a suitable, spacious, industry-like laboratory for the extraction of radium and was an experienced, innovative chemist already familiar with radioactive elements, having worked with thorium. Haitinger carried his skills as experimenter from the Chemistry Institute to Welsbach's industry and his dexterity with financial issues back to the domain of science.

In 1901 Suess and Lang drafted a letter to Auer von Welsbach on behalf of the Austrian Academy. They proposed to involve him in radium research by using his laboratory either under his or Haitinger's directorship. "Such a research," as Suess

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collaboration of chemists and physicists with industrialists, as Boudia emphasizes, played an important role to the construction of the radioelement industry in France.

[47] Anonymous, "Carl Auer von Welsbach," (1912).

[48] Haitinger studied chemistry at the University of Vienna and worked as an organic chemist before he accepted a position at Auer von Welsbach's industry in 1887. Although trained as a scientist, Haitinger's role soon shifted to that of industry manager. One of his new tasks was to arrange the exportation of Auer von Welsbach's gas lamp to the United States. Three years later he quit his position, returned as an adjunct to the Chemistry Institute, and at the same time he worked on the improvement of Auer von Welsbach's invention. The technician and chemist won over the industrial manager but only until 1892, when Haitinger returned to the factory as director (*Chemiker-Zeitung*, "Haitinger-Feier," (1930), p.182.)

and Lang explicitly stated, "cannot be carried out by ordinary aid." [49] Obviously the work on radium introduced a unique and novel cooperative tone into experimentation as chemists and physicists were forced to collaborate with industrialists. Shortly after Auer von Welsbach's agreement, the Academy's *Commission for the Investigation of Radioactive Substances* was finally formed, chaired by Exner, and Suess, with Boltzmann, Lang, and Auer von Welsbach as members.[50] Radium was the boundary object that they all shared.

The next step for the Austrian Academy was to ensure adequate amounts of radium for research. On 15 January 1904, Suess and Lang addressed the Ministry of Agriculture, asking for the amount of 20,000 kg residue. As they argued, "For many years no phenomenon has affected the scientific world in such an extraordinary way as the observation of the strange appearances of radium, a substance, that is according to phenomena, an inexhaustible source of light and heat, and thus seems to contradict fundamental assumptions of today's physics."[51] The very same day, Suess and Lang emphasized the importance of radium research to the Ministry of Culture and Education. To strengthen their argument they focused on the Nobel Prize, awarded to the Curies for their discovery of radium and the crucial role that Austrians played by providing the radioactive material. They did not fail to mention the French Academy's financial support of the Curies by an amount of 155,000 Francs.[52] Between the lines, Suess and Lang implied their own demand for financial support.

While they emphasized the need for a "parallel, up to date line" of research in Vienna comparable to that in Paris, Suess and Lang also negotiated low prices for the pitchblende with the Ministry of Agriculture. Both research groups, in Paris and Vienna, needed 4 grams of radium, which meant at least 10,000 kg of residue apiece. Since the annual production of the mines was only 6,000-7,000 kg of residue, it might be more than two years that such quantities were available. The negotiation was not an easy one. The Academy could only affirm that the radium would be used for strictly scientific reasons and that the research was innovative and absolutely important.[53]

[49] Suess to Auer von Welsbach, July 10, 1901, AÖAW.
[50] Reiter, "Stefan Meyer," (2001), p. 111.
[51] Suess and Lang to the Ministry of Agriculture, January 15, 1904, AÖAW, (translation mine).
[52] Suess and Lang to the Ministry of Culture and Education, January 15, 1904, AÖAW.
[53] Suess and Lang to the Ministry of Agriculture, January 15, 1904, AÖAW.

The deal was eventually closed in March 1904.[54] The mines provided the Academy the amount of 10,000 kg residue in two parts and received 8,040 Kronen. Auer von Welsbach's industry was well compensated for the space provided and for the chemical elaboration of the residues. In 1904 Welsbach received 3,064 Kronen and after the extraction of radium an additional 6,121 Kronen.[55] Part of the amount came from a donation that Haitinger made to the Academy in the form of a prize for scientific research in his father's memory.[56]

Working painstakingly for two years, Karl Ulrich and Haitinger extracted 4 gr radium bromide out of 30 tons of pitchblende by transferring laboratory methods to the factory and extending their practices to industry.[57] At the same time they shifted the culture of science from an enterprise focused on teaching and modest experimentation to a modern, relatively expensive research practice. Eventually the extracted radium constituted the main radioactive material used at the Institute for Radium Research.[58] "With it," as Meyer later recalled, "had been laid down the basis for systematic research in this field in Austria,"[59] and as Exner acknowledged, it elevated the Institute to one of the richest centers in radioactive materials.[60]

The Curies were regular customers for pitchblende. In addition, the Royal Society of London placed a similar request on 1 May 1904. The English were ready to buy the portions of residues that were not set apart for the Curies.[61] Three years later, while both William Ramsay in London and Rutherford in Manchester were involved in radioactivity research, the Austrian Academy loaned 350mg of radium bromide to the Englishmen after their persistent requests. Highly respected as he was, Meyer played the role of the mediator. The collaboration of Ramsay and Rutherfod soon

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[54] Pawkowicz, *Die Österreichische Akademie der Wissenschaften,* (1978), p. 67. On March 7, 1904 Suess and Lang informed Pierre Curie of their agreement with the Ministry of Agriculture. Given the shortage of the residue, they offered that the two research groups, the Austrians and French, would alternate in receiving 1 ton each at a time (Suess and Lang to Pierre Curie, March 7, 1904, AÖAW). On March 22, Lang and Suess informed the administrators of the St. Joachimstal mines of the above procedure. The mine's administrators should send alternatively one ton of pitchblende to Atzgersdorf, Vienna and one to Paris. Further financial issues were clarified (Suess and Lang to k.k. Berg- und Hüttenverwaltung, St. Joachimstal, March 22, 1904, AÖAW). Between 1904 and 1905 the Curies paid 9,540 kronen to the mines for the residues (Meyer, "Die Vorgeschichte" (1950), p. 9).

[55] Meyer, "Die Vorgeschichte," (1950), p. 10.

[56] *Chemiker-Zeitung*, "Haitinger-Feier," (1930), p.182.

[57] Haitinger and Ulrich, "Berich über die Verarbeitung," (1908), pp. 619-630.

[58] *Chemiker-Zeitung*, "Haitinger-Feier," (1930), p.182.

[59] Meyer, "Das erste Jahrzehnt," (1920), p. 1.

[60] Exner, "Le nouvel institute," (1910), p. 244.

[61] The Royal Society to the Austrian Academy, May 1, 1904, AÖAW.

proved to be unfortunate since the first insisted on keeping the radium for one and a half years, making only radon available to the latter. In 1908 a second loan, this time of 170 mg of radium as 300 mg of radium bromide, was sent exclusively to Rutherford for his own experiments.[62]

While English and French scientists had already embarked fully on radioactivity research, Emil Warburg, president of the *Physikalisch-Technische Reichsanstalt*, a physics institute in Berlin, was trying to transform his laboratory into a leading scientific center. As David Cahan notes, by the start of Warburg's presidency in 1905 the Institute was not able to meet the demands of contemporary science.[63] Radioactivity was a promising field and Warburg knew the place to start. "I now intend to carry out several works on radioactivity," he wrote to Exner in 1909, "and allow me the following question, whether it is possible to let us have a loan of a small quantity of radium bromide for this purpose."[64]

"First for free and then for moderate prices," as it is documented in one of the Academy's reports, the *Commission for the Investigation of Radioactive Substances* "had already provided radium to a large number of institutes in France and Germany."[65] By the end of the first decade of the 20th century, radium already inhabited several intersecting social worlds. Although it more or less retained its chemical identity,[66] it was absolutely plastic, adapting to the needs, constraints, and goals of the several parties deploying it. Shared between chemists and physicists, radium threatened the disciplinary unity of both and forced them to cooperate with each other. For each one, it carried a different meaning as it did for the various institutes involved in radioactivity research. The discovery of radium provided the Curies with the prestige that they both were lacking when they worked at the EPCI. They also acquired new space and apparatus to continue their experiments. Warburg based on radium the transformation of his institute in Germany into a leading scientific center. For the English, research on radium was a way to express their aim

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62 Rona, *How it Came About,* (1978), p. 21.
63 Cahan, *An Institute for an Empire,* (1989), p. 8.
64 Warburg to Exner, February 12, 1909, AÖAW.
65 Kaiserliche Academie der Wissenschaften in Wien, Konzepte, 25 015, AÖAW. For example a list of radium recipients included the Chemistry Institute in Krakau and Eduard Riecke's Institute at the University of Göttingen (1908 report of the Ministry of Public Affairs, n. 904, AÖAW).
66 During the first years of radioactivity research, radium did not have even a robust chemical identity since most of its properties were still under investigation.

to maintain their leadership in physics. For the Austrians radium meant actually much more.

After the painstaking work of separating radium from pitchblende, Ulrich gained the directorship of the St. Joachimstal mines, acting as the key link between the Bohemian industry and his colleagues in Vienna.[67] Auer von Welsbach, with a serious commitment to both science and industry, was challenged by the opportunity to contribute to fundamental research and also embark on new industrial achievements with a significant financial benefit. By using radium as a bargaining tool, the Ministries of Agriculture and Education of the dual Austro-Hungarian Monarchy, located in Vienna, exercised their political strength over the other half of the empire.[68] Austrian academicians such as Suess and Exner proved their administrative talents along with their scientific ones by serving as mediators among the Austrian ministries in charge, their international colleagues, and the directors of the Bohemian mines.[69] Exner and the Austrian physicists foresaw in radium research the emergence of an exciting scientific field. Thus, to just administer the radium sources in St. Joachimstal and to play the role of radium merchants was not part of their goals. As Suess and Lang argued, they had "a kind of moral obligation to the whole scientific world" to pursue research on radium.[70] Although not explicit, for them radium actually meant much more. It became eventually the vehicle for obtaining a new Physics Institute, appropriate to the prestige of the Viennese physicists.

c. Between Physicists and Physicians

The discovery of radium brought physicists into another kind of intimate collaboration that they had not anticipated. Although physicists and chemists had been offering their knowledge to medical and pharmaceutical students in the big lecture halls of Währingerstrasse 10 and the *Josephinum*, their cooperation ended at the doors

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[67] Meyer, "Die Vorgeschichte," (1950), p. 14.

[68] For characterizations of Austria as the center of the monarchy's power see Okey, *The Habsburg Monarchy,* (2001), p. 196.

[69] When the Austro-Hungarian Empire collapsed, Ulrich lost his position as director at the St. Joachimstal mines and moved to Vienna as a guest at the Institute for Radium Research (Meyer, "Das erste Jahrzehnt," (1920), p. 11).

[70] Suess and Lang to the Ministry of Culture and Education, March 14, 1908, AÖAW.

of the infirmaries and surgical rooms. Physics and chemistry laboratories were widely open to physicians for educational reasons. Yet, the medical clinics and operating rooms were mainly closed to physicists. But when it came to using radium for therapeutic purposes the only way to bring it into the medical facilities required opening the doors to physicists and chemists. As the case of the Viennese physician Leopold Freund illustrates, the development of a trading zone between physics and medicine, which later became known as radiotherapy, raised questions of authority and drastically reshaped disciplinary boundaries.

Freund was the first to suggest that x-rays produce biological effects and can be used as a medical tool.[71] As he recalled later, in 1896 a Viennese newspaper reported a case of dermatitis and epilation of an American engineer who worked with x-rays. At the time Freund was working under the dermatologist Eduard Schiff in the institute for pediatric medicine in Vienna.[72] It was there that he encountered an eight-year old girl suffering from a hairy nevus on her back.[73] His immediate idea was to expose the back of the young girl to x-rays hoping to achieve the epilation of the region. With the mother's consent, Freund turned to those local clinics and institutes that owned a Röntgen apparatus and argued for his case. Physicians were "very skeptical and they objected to it," as Freund recalled, arguing that their patients never presented any biological effect even when they were exposed to the apparatus for a long time.[74] Although physicists were slowly obtaining more space within the physicians' territory, the Röntgen apparatus was exclusively used for diagnostic purposes, a handy tool to the medical practitioners. To argue that the same apparatus had biological effects was a threat to the physicians' self-sufficiency within their clinics. It seemed to them that the physicists were taking an active role in controlling human biology.

Finally Freund had to perform his medical treatment in an odd place: the Viennese Imperial Institute for Research in Photography and Reproduction

[71] Kogelnik, "The History and Evolution of Radiotherapy," (1996), p. 219. For the original publications see Freund, "Ein mit Röntgen-Strahlen," (1897), pp. 428-434; Freund, "Nachtrag," (1987), pp. 856-860.
[72] Freund, "Originalabhandlungen," (1937), p. 147.
[73] Alth, "Die Geschichte der Strahlentherapie," (1981) p. 4; Freund, "Originalabhandlungen," (1937), pp. 147-153.
[74] Freund, "Originalabhandlungen," (1937), p. 147.

Procedures.[75] To the surprise of physicians and even that of physicists, the experiment was successful. Epilation appeared after three treatments. In 1897 Freund presented his case to the Viennese Medical Society. He had to rely on his advocate, the leading dermatologist Moritz Kaposi and one of the first radiation biologists, to smooth the objections of the medical community.[76] Immediately afterwards, Josef Tuma, secretary of the Chemical-Physical Society, invited Freund to present the outcomes of his experiment to one of his Society's regular meetings.[77] Apparently, the physicists were anxious to challenge Freund's research. During the meeting "there developed an extremely lively debate between two gentlemen unknown to me," as Freund recollected.[78] The "unknown gentlemen" were Ernest Mach and Ludwig Boltzmann, who both doubted, "full of temperament," Freund's claim that x-rays could induce biological effects.[79]

Within the next five years radiotherapy was widely practiced in Austria, and Europe in general, and the cooperation of physicists and physicians was impressively improved.[80] Physicists were hired as Röntgen Ray Operators and as personnel for the technical support of the Röntgen equipment; doctors collaborated with them on improving their medical instruments.[81] At the same time an industrial chemist working in Germany, Friedrich Giesel, was the first to observe that radium had biological effects as well. By deliberately applying radium barium bromide to his arm,

[75] Kogelnik, "The History and Evolution of Radiotherapy," (1996), p 221.
[76] Kogelnik, "Inauguration," (1997), p. 208.
[77] Tuma was Exner's student and his assistant from 1891 to 1893 when he moved to Lang's *Physikalische Kabinet* (Karlik and Schmid, *Franz Serafin Exner,* (1982), pp. 141-142).
[78] Freund, "Originalabhandlungen," (1937), p. 147 (translation mine).
[79] Freund, "Originalabhandlungen," (1937), p. 147. See also Kogelnik, "The History and Evolution of Radiotherapy," (1996), p 221.
[80] In most of the big European hospitals of the time, physicians followed Freund's pioneering work and adopted his technique. For the case of France see Tubiana, Dutrei, and Pierquin, "One Century Radiotherapy in France," (1996), pp. 219-226. For the case of Germany see Heilmann, "Radiation Oncology," (1996), pp. 207-217. For the case of Austria see also Wyklicky, "Zur Geschichte der Strahlentherapie" (1980), pp. 165-170. For the case of England see Fox, "The History of Radium," (1998), pp. 115-124. For the case of Denmark see Sell, "The Development of Radiotherapy," (1995), pp. 1005-1010. For the case of Poland see Hliniak at al, "An Outline of the History of Radiation," (1996), pp. 799-802. For the case of Finland see Holsti, "How Radiation Oncology Emerged," (1996), pp.793-798.
[81] Fox, "The History of Radium," (1998), pp. 115-116. The first catalogue of x-ray equipment was produced by *Reininger, Gebbert, and Schall,* an electrotechnical firm, forerunner of the *Siemens* company. The catalogue was published in 1897, demonstrating the interplay of physics, medicine, and industry. It is noteworthy that just a year after Röntgen's discovery, the industrial production of x-ray tubes was under way (Mould, *A Century of X-Rays* (1993), p. 36).

Bequerel confirmed Walkhoff's observation that radium causes skin wounds.[82] Bequerel and Pierre Curie repeated the experiment and immediately published their results.[83] A picture of Curie's injured forearm after his self-exposure to radium appeared in a French newspaper, bringing the news to the general public.[84] The above findings intrigued the medical practitioners. Given the effects of radium on human tissues, many physicians became excited about the possibility of using radium in the treatment of cancer. Pierre was the first to instantiate the interrelation of physics to medicine through radium. He offered a tiny amount of the valuable element to Henri Danlos, a dermatologist at the Hospital Saint-Louis in Paris, who put it to good use by treating some cases of lupus.[85]

The development of radium therapy was astonishingly rapid. Biologists, physiologists, and clinical practitioners explored the effects of radium on a number of different human tissues, the nervous system, the eye, as well as on plants and animals. Working on radium, Viennese physicians tied their culture as medical practitioners to that of physicists. They were forced to learn the physics of the new element, to puzzle over the way radiation is absorbed by the human body and its dosimetry, and to find the appropriate ways to measure it.[86] Sigmund Exner carried radium research over to

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[82] Walkhoff published a brief description of a skin reaction to radium in October 1900. Interestingly enough, he published his report in a journal of amateur photography. This reminds one of Freund's choice to perform his experiment in an institute for research in photography and calls attention to the interrelation of physics, medicine, and photography. (Walkhoff, Unsichtbare, photographische wirksame," (1900), pp. 189-191. See also Dutreix, Tubiana and Pierquin, "The Hazy Dawn of Brachytherapy," (1998), p. 223.)

[83] Bequerel and Curie, "Action physiologiques," (1901), pp. 1289-91. As Mould correctly emphasizes, Piere Curie and Bequerel planned their experiments and they were not accidental (Mould, "The Discovery of Radium," (1998), p. 1241.)

[84] Surprisingly, radium started to occupy the interest not only of physicists and physicians but also of general public. For example, in 1903 the American inventor Thomas Edison warned the public of radium's possible damaging biological effects in an interview in *Penny Press* (see Mullner, *Deadly Glow*, (1999), p. 16.)

[85] Tubiana, Dutreix, and Pierquin, "One Century of Radiotherapy," (1996), p. 231; See also Viol, "History and Development of Radium Therapy," (1921), p. 21.

[86] Besides the Austrians, the French were also seriously engaged in the field of radium therapy. Industry, medicine, and physics were all combined in the *Laboratoire Biologique du Radium (LBR)* that was established in Paris in 1906. Armet de Lisle, an industrial chemist, collaborating with the Curies' laboratory, foresaw the financial benefits of radium and its medical applications as early as 1904 (Boudia, "The Curie Laboratory," (1997), p. 251). He established a radium factory in Nogent-sur-Marne and two years later he patronized the founding of the *Laboratoire Biologique du Radium* (Tubiana, Dutreix, and Pierquin, "One Century of Radiotherapy," (1996), p. 231). Thus, at least in case of France, industry was closely bound to physics, chemistry, and medicine. In the following years a considerable number of radium therapy centers were found throughout Europe. In 1908 the first center for cancer was established in Stockholm at the university clinic of the Karoline Institute where the gynecologist James Heyman developed his method of radium treatment of cancer of the uterus. Two years later a similar center was established in Heidelberg by the physician Vinzenz Cerny. In Vienna a

physiology by studying its effects on animal tissues.[87] Alfred Exner and Guido Holzknecht were the first Austrian physicians to probe the pathology of radium dermatitis.[88] In 1902 Holzknecht became a pioneer in diagnostic radiology, developing the first instrument to measure x-rays. His device, the chromoradiometer, attracted the interest of the international community of physicians and the same year Antoine Beclère, an outstanding pioneer of radiology in France, visited Holzknecht in Vienna to discuss dosimetry issues.[89] Besides elevating radiology to an exact science, Holzknecht worked with radium as well. In June 1903 Holzknecht joined Gottwald Schwarz, later director of the Röntgen station at *Elisabeth-Spital*, in a study of the possible atrophy of the optical nerves due to radium. Their article appeared in the *Mitteilungen* of the Society of Physicians.[90] In 1905 Holzknecht took over the leadership of the Röntgen Laboratory of the second Medical University Clinic of Vienna, later known as the Holzknecht Institute.[91]

To physicians working on radium therapy, the most astonishing feature of their experimental treatments was that they were rather successful. Indeed radium proved very useful in medicine. But this very power meant that physicists started to intrude into the domain of health. The early methods of radium therapy required the close cooperation of physicists and physicians. The devices were crude and of two main kinds; a) the flat applicators (radium plaques), which were flexible or rigid, designed for external use, and b) the spherical ones used in endocavitary applications. They contained a quantity of radium power proportionate to the area for treatment. Later on, physicists, responding to physicians' needs, designed more sophisticated

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radiological institute was founded at the Lainz hospital in 1913 and Heyman's methods were soon used for treatments of cancer (Alth, *50 Jahre Strahlentherapie Lainz,* (1981), p. 4-5; Luger, *70 Jahre Krankenhaus* (1977), p. 3; Mould, *A Century of x-rays,* (1993), p. 136). It was not until 1931 that a specialized radium therapy center for cancer and a Radium Station were finally established in Austria under the auspices of Julius Tadler, the Social Democratic minister of health (Alth, *50 Jahre Strahlentherapie Lainz,* p. 12).

[87] Exner,S. "Einige Beobachtungen," (1903), pp. 177-79.

[88] Exner, A. and Holzknecht, " Die Pathologie," (1903), pp. 155-162. Alfred Exner was the first to treat tumor of the esophagus by forcing a catheter that held the radioactive source through the esophagus so as to achieve improvement in swallowing (Exner, A. "Über die Behandlung," (1904), pp. 4-96).

[89] Tubiana, Dutreix, and Pierquin, "One Century of Radiotherapy," (1996), p. 228.

[90] Fischer, *Geschichte der Gesellschaft der Ärzte*, (1938), p. 156.

[91] In 1910 Holzknecht joined Freud's psychoanalytical society after experiencing psychological anxieties. More than two decades later, in 1931, Holzknecht treated Freud's tumor in his institute (Angetter, *Guido Holzknecht,* (1998), pp. 16-17).

devices, such as steel needles containing capillary glass tubes filled with radon.[92] Treatment was based on needle puncture. Given the lack of a suitable method for standardizing radium preparations, the expanded use of radium in cancer therapy enforced an intimate relation between physicists and physicians. Physicians were in desperate need of accurate methods of radiation measurement. Their major concern was the precise description that could ultimately lead to successful duplication of their work. It was physicists who had the expertise and the instrumentation to do so.

Besides constructing instruments for medical use and suggesting appropriate radium dosages, physicists also designed curative baths. In June 1904, Heinrich Mache, Exner's student and *Assistent*, conducted the first study of the water at the famous health spas in Gastein. Bubbling air through bottles completely filled with the Gastein water, Mache obtained emanation that he soon concluded was due to radium minerals in the earth's crust.[93] Within the next three months he completed his experiments, giving a much fuller account of the amount of radioactive emanation in the water.[94] Soon thereafter, Meyer joined Mache and expanded their investigations to other springs such as Carlsbad, Marienbad, Teplitz-Schönau-Dux, Franzensbad, and St. Joachimstal. Their results varied but the St. Joachimstal water proved to contain the largest amount of emanation ever found in any spring water. Given that the radium content in the ground was high, Mache's earlier conclusion proved to be right.[95] The presence of radium emanation, later called radon gas, in the spring water explained its therapeutic properties. In 1904 Mache proposed a measurement unit for the concentration of radon in water that took his name.[96]

The Austro-Hungarian Monarchy under the supervision of Mache and Meyer, hastened to establish a curative Bad at Joachimstal.[97] Visitors came from near and far to soak in the effective water and inhale the air. The dynamic of radium was unpredictable and the social worlds that it inhabited were multiplying very rapidly. A luxurious bath was built and inhalation apparatuses were designed. Patient prescriptions were given in Mache units. As Meyer claimed later, concerning the

[92] Tubiana, Dutreix, and Pierquin, "One Century of Radiotherapy," (1960, p. 231; Also for illustrations of early radium therapy equipment and methods see Mould, *A Century of x-rays,* (1993), p. 27, 131.
[93] Mache, "Über die im Gasteiner Wasser," (1904), pp. 441-444.
[94] Mache, "Über die im Gasteiner Wasser," (1904), pp. 1329-1352.
[95] Mache and Meyer, "Über die Radioaktivität der Quellen," (1905), pp. 355-385.
[96] Mould, *A Century of x-rays,* (1993), p. 170.
[97] Meyer, "Die Vorgeschichte," (1950), p. 3.

medical uses of radium, "Austria was in this respect the best country by means of research."[98] In the following years, hospitals' demands for radium increased quickly together with the establishment of radium laboratories within their facilities. By 1908 the Austrian Academy of Science had already provided radium to a number of hospitals such as the general hospital and university clinics in Vienna and the university clinic in Krakau.[99]

The interest in radium emanations for medical use was so great that apparatus to produce radioactive water quickly became commercially available. For example, the *Radiumwerk Neulengbach,* a commercial supplier for radon, opened up an office within the *Mediziner-Viertel* at Günthergasse 1 close to Türkenstrasse. They advertised their product as being as radioactive as the natural springs and effective for a list of medical problems such as neuralgia, neurosis of the digestive organs, and malignant neoplasm.[100] Apparently, radium was slipping out of the physicists' hands to the hands of the entrepreneurs. Although Suess, Exner, and his colleagues at the *Commission for the Investigation of Radioactive Substances* were playing an important and prestigious role in providing radium to the scientific community and establishing curative baths, they were still "homeless" investigators in the spinning world of radioactivity research. The need of a new specialized institute became pressing as never before.

3.2. The Establishment of the Institute for Radium Research

> I wanted as far as it was within my power, to prevent the shame of falling on my fatherland that the scientific exploitation that nature conferred upon it as a privilege would be snatched away by others. I had no other choice, under the somewhat cumbersome governmental procedures and really pressing circumstances, than to reach into my own pocket and at least to try to smooth the path.[101]

In his letter to the Austrian Academy of Sciences Carl Kupelweiser made explicit what Exner and his circle were trying to avoid; to become the radium

[98] Meyer, "Die Vorgeschichte," (1950), p. 3 (translation mine).
[99] Report of the Ministry of Public Affairs drafted in 1908 n. 904, AÖAW. In 1904 Suess was interviewed by Louis Leasley from London. On his return to London, Leasley asked Suess for a radium loan in order to pursue "hospital work" (Leasley to Suess, February 18, 1904, no. 25 083, AÖAW).
[100] "Re Präparate," newspaper clip, undated, AÖAW.
[101] Kupelweiser to the Academy of Sciences, August 2, 1908, AÖAW.

merchants for their international colleagues. National and scientific shame would have been devastating for bourgeois scientists such as Exner, who grew up with the secure feeling of belonging to an empire. In the midst of the *Commission*'s negotiations for radium supplies with the Curies, Rutherford, and a number of international institutes and clinics, a generous offer prevented the embarrassment. On 2 August 1908, Kupelweiser addressed a letter to the Academy of Sciences explaining his initiative to donate 500,000 Kronen, a grandiose sum for the time, for the establishment of "an institute to serve research on radium by physics."[102] A Viennese lawyer and a powerful industrialist, Kupelweiser was the son of the famous painter Leopold Kupelweiser. His father was member of an artistic circle including the painter Moritz von Schwind, the musician Franz Lachner, and the composer Franz Schubert. His family was also acquainted the families of Ludwig Wittgenstein and Franz Exner.[103] As a true-born bourgeois, Carl Kupelweiser had an interest in the cultural and political life of Vienna. At the time, radium and Exner's circle promised him both. Kupelweiser had already indicated his interest in academic politics in 1907 when he generously patronized the Biological Station in Lunz. It was not by chance that the first director of the station was his son, the biologist Hans Kupelweiser.[104] The Institute for Radium Research was his second attempt to actively influence the academic politics and science in Vienna. Like the generous patrons of the Italian Renaissance, Kupelweiser aimed to boost his prestige and play an active role in the academic scene of Vienna.[105]

During the next two years, with his private initiative Kupelweiser achieved what Exner and his colleagues had not managed to do despite their persistent attempts for over a decade: to establish a new physics institute. The negotiations with the sloppy bureaucratic system of the Austro-Hungarian Monarchy and its ministries were Kupelweiser's expertise. Being a lawyer, he knew the tricks. His donation set the officialdom into frenzied action. Since 1894 the administrations of the Ministries of Education and Finance had been in constant negotiations about the site where the

[102] Pawkowicz, *Die Österreichische Akademie,* (1978), p. 70.
[103] Löffler, "Limnology in Austria," (2001), p. 15; Reiter, "Vienna: A Random Walk," (2001), p. 476.
[104] Löffler, "Limnology in Austria," (2001), p. 15.
[105] Reiter, "Stefan Meyer," (2001), p. 114. With his generous offer, Kupelweiser did not intend to profit from radium industry but instead, he wanted to patronize science. His involvement with the Viennese scientific society as a patron is further suggested by his additional donations to the medical society of Vienna. (Fischer, *Geschichte der Gesellschaft der Ärzte*, (1938), p. 115).

physics institute should be established so it could move out of the shabby building at Türkenstrasse. Nevertheless, bureaucracy and lack of money delayed ground breaking for the Physics Institute for about fifteen years. Physicists were impatient and frustrated. The building at Türkenstrasse was absolutely insufficient to house research on radioactivity given the new demands on space and for specialized instrumentation. Already on 14 March 1908, Suess and Lang had written the Ministry of Culture and Education, fighting their case. "The new building for the Physics Institute is an essential condition for the possibility of radium research, since the current one is absolutely useless for such exact studies." [106] When Kupelweiser offered his donation five months later, both physicists and the state seized the opportunity without hesitation.

Kupelweiser's donation was explicitly designated for the building and the founding of the Institute for Radium Research. An inviolable condition was that the state should provide a site next to the new Physics Institute. Soon after Kupelweiser's generous offer, the Ministry of Education decided upon a spacious plot of land, which was located across the *Josephinum* and at the intersection of Boltzmanngasse (Waisenhausgasse then), Währingerstrasse, and Strudlhofgasse (Versorgungshausgasse then). [107] Not surprisingly, the chemists did not remain idle. Their institute at Währingerstrasse 10, although architecturally impressive, proved to be small from the moment it opened its doors in 1872. On the one hand, given the industrial need for chemists, the field was rapidly expanding.[108] On the other hand, Auer von Welsbach's and Haitinger's entry into radioactivity research opened up a whole new field, that of radiochemistry. Thus it did not seem unreasonable for chemists and physicists to share the same site for their institutes. The ongoing arrangements for grouping together the Institute for Radium Research with that of Physics struck Rudolf Wegscheider and Zdenko Skraup, directors of the first and second Chemistry Laboratories, as their chance to obtain a new institute. Eventually, on 5 June 1909, the state approved the construction of a complex of buildings on the

[106] Suess and Lang to the Ministry of Culture and Education, March 14, 1908, AÖAW.
[107] Hittner, *Geschichte des Studienfaches Physik,* (1949), p. 73.
[108] For example, the Austrian chemical company *Aussiger Verein,* located at Aussig on the Elbe in Bohemia, played a leading role in the production of heavy chemicals in all over central Europe. The laboratory of the company employed six to eight chemists and a number of necessary assistants (Oberhummer, "The Leading Chemical Company," (1997), p.304). The textile industry was also in need of a considerable number of chemists.

triangular piece of land defined by Boltzmanngasse, Währingerstrasse, and Strudlhofgasse designed to host a Physics Institute, a Chemistry Institute, with a small building devoted to radium research in between.[109] On 28 October 1910, the Institute for Radium Research opened its doors as the first specialized institute on radioactivity.[110] As Victor Hess later recalled "it was the only one of its kind in the world. It was a true pleasure to have all of these excellent apparatuses and facilities at one's disposal."[111] Exner was the official director (*Vorstand*) and Meyer was the director (*Leiter*) in charge of the edifice, arranging the purchase of instruments and furniture.[112] Construction continued on both sides until the Physics Institute opened in 1913 and the Chemistry in 1915.[113]

The research carried out during the first decade of the Institute's function led to at least two Nobel Prizes in later years and involved a surprising number of young creative researchers with backgrounds in fields such as biology, physiology, chemistry, geology, and physics. Hess, the first Institute's *Assistent* until his departure to the Unites States in 1920, received a Nobel Prize in physics in 1936 for the discovery of cosmic radiation in 1912.[114] Friedrich Paneth worked as the second *Assistent* from 1912 to 1919 [115] and, in collaboration with Georg Hevesy, conducted the first radioactive-tracer experiment in 1913. His main research concerned the investigation of radium and lead isotopes that later led to their clinical use. On this basis, Hevesy received the Nobel Prize in chemistry in 1943. Otto Hönigschmid was responsible for the production of radium standards. Hans Molisch, later president of the University of Vienna, embarked upon his scientific career with a study of the influence of the radium emanations on plants.[116] Heinrich Mache and Eduard Suess

[109]Protokoll, k.k. Academie der Wissenschaften, Institut für Radiumforschung in Wien, Neubau, 5 June 1909, AÖAW.
[110] Meyer, "Die Vorgeschichte," (1950), p. 13.
[111] Reiter, "Stefan Meyer," 2001, pp. 114-6. As Reiter argues, the Institut du Radium in Paris, which opened in 1915, architecturally resembled the Vienna Institute.
[112] The letters concerning the construction and furnishing of the Institute were all addressed to Stefan Meyer. See for example the files *Bau des Instituts, Erstausstattung*, AÖAW.
[113] Hittner, *Geschichte des Studienfaches Physik,* (1949), p. 76; Schönfeld and Ipser, "Die Geschichte der Chemie," (1996), p. 22.
[114] Hess, "Persönliche Erinnerungen," (1950), p. 43-45.
[115] Liste der Assistenten, 1934, AÖAW. See also Meyer, "Das erste Jahrzehnt," (1950), p. 11.
[116] Molisch, "Über der Einfluss der Radiumemanation," (1912); Molisch, "Über das Treiben der Pflanzen," (1911).

worked on the absorption of radium emanations in human blood through inhalation and drinking.[117]

After its establishment, the Institute became the official radium standard keeper for radioactive measurements in Austria, acting as an information center for scientific questions related to radium. It also supplied the Radium Station at the Vienna's General Hospital with radium for medical use.[118] Devoted exclusively to research, the Institute offered possibilities only for *Praktikum*, i.e. laboratory research positions for Ph.D. candidates to complete their thesis requirements.[119] Exner and his colleagues gained well-equipped laboratories. Most importantly thought, they institutionalized radioactivity research, boosted their prestige, and elevated their scattered research activities to a new scientific field. By maintaining their relations to the medical institutes and industry, they stabilized and strengthened the connecting passages of radioactivity to medicine, clinical radiology, and industrial chemistry.

3.3 Entering the Field of Radioactivity: Women at the Institute for Radium Research in Vienna, 1910-1920.

In the crossroad of physics, chemistry, and medicine, women found it convenient to enter the field of radioactivity, taking advantage of its interdisciplinarity. From 1910 to 1920 eight women out of forty-eight authors published work in the *Mitteilungen*, the annual bulletin of the Institute. Taking into account the canonical stories of women's invisibility in the physical sciences, the percentage of women authors (16.7%) is surprising.[120] Each of those women came into radioactivity by a different route and each of them had a different life pattern.

With a strong background in physics and mathematics, Helene Souczek entered the Institute in 1910 as a research student. Haitinger and Ulrich had already extracted radium chloride from pitchblende from the St. Joachimstal mines. Souczek's dissertation topic was on the measurement of radium content of the pitchblende

[117] Mache and Suess, "Über die Aufnahme von Radiumemanation," (1912).
[118] Meyer, "Das erste Jahrzehnt," (1920), p. 12.
[119] Meyer, "Das erste Jahrzehnt," (1920), p. 10. For a detailed description of the Austrian academic system see also Taussky-Todd, "An Autobiographical essay," (1985), p. 316.
[120] The percentage of 16.7 refers to the number of women authors from 1910 to 1919. The proportion of articles that were published or co-authored by women is 8.6%. The first volume of the *Mitteilungen*

residues. In 1910 she published her results in the *Mitteilungen*.[121] Her examiners were Franz Exner, Friedrich Hasenöhrl, and Franz Mertens. Hasenöhrl was the physicist who took over the directorship of the Institute for Theoretical Physics after Boltzmann's death and Mertens was working at the Institute of Mathematics. Despite the stereotypical image of single women pursuing scientific research, devoted to their science, Souczek was married. She was born as Helene Ludwig, daughter of the councilor Ernst Ludwig in Salzburg, and married Adolf Souczek before she completed her studies.[122]

To enter the Institute, Friederike Friedmann used her experimental skills in physics. Her research topic was on testing the theoretical hypothesis concerning the variations in the range of alpha particles. In the early days of radioactivity research the main problem was to determine the chemical identity of the new elements, define their properties, and explain the decay-series transitions. One way to determine atomic weights was by calculating the number of alpha transitions from the known elements such as uranium, radium, and thorium. Thus, the properties of alpha radiation were essential in the identification of elements. Friedmann made an experimental investigation of the variations in the range of individual alpha particles emitted from a source. The fact that all alpha particles did not penetrate the exact same distance in air was tested statistically by Karl Herzfeld in 1912.[123] It was Friedmann who, in 1913, offered an experimental confirmation of Herzfeld's theoretical results for the case of polonium.[124] In order to gain greater technical expertise for her experimental work, Friedmann sought further education at the *Technische Hochschule Wien.* Bringing back her technical knowledge and experimental skills, Friedmann remained at the Institute until 1919.[125]

Stefanie Horovitz took a different route. Chemistry and her connection to Lise Meitner opened the door to the Radium Institute for her. In 1913 Frederic Soddy succeeded in placing all the known radioelements in the periodic table, despite the fact that there were more of them than the available places. He did so by locating

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includes articles of Ernest Rutherford, Bertram Boltwood, and William Ramsay that I did not take into account for calculating the above percentages.

[121] Souczek, "Messungen des Radiumgehaltes," (1910), pp. 371-76.

[122] Bischof, *Frauen am Wiener Institut,* (2000), p. 61.

[123] Herzfeld, "Über die Schwankungen der Reichweite," (1912), pp. 547-550.

[124] Friedmann, "Experimentelle Bestimmung," (1913), pp. 1269-1289.

[125] Bischof, *Frauen am Wiener Institut*, (2000), p. 62.

more than one radioelement in the same box based on the elements' atomic numbers. Soddy's discovery of isotopes brought up the need for a series of comparative atomic weight determinations. His experimental approach was through wet chemical techniques. Despite the fact that these techniques were more reliable than electrochemistry, they were also more painstaking. The difficulty was in completely isolating the elements and identifying the short-lived beta-emitters. In Vienna, Hönigschmid, already involved in the meticulous task of preparing radium standards, was one of the few to grasp the chemical techniques for the identification of radioelements. The aim was to determine the atomic weight of the inactive lead that was the end-product of the uranium decay series, which was thought to be the end of thorium's chain as well.[126] In January 1914, Hönigschmid asked Meitner, who was already in Berlin, whether she knew of someone qualified to work on such a project.[127] The advantage of acting within a space such as the *Mediziner-Viertel,* where scientific institutes were within walking distance of each other, was that the few women in science were absolutely visible. Although she had worked at the Physics Institute at Türkenstrasse, Meitner remembered Horovitz, studying under Guido Goldschmiedt at the second Chemistry Institute at Währingerstrasse 10. Thanks to Meitner's recommendation, Horovitz was offered the job. As Hönigschmid wrote to Meitner a few months later, "I am sending you greetings from Miss Horovitz, who does not believe that you still remember her. I have just argued with her about that."[128]

Horovitz was a young chemist who had just graduated from the University of Vienna.[129] Wet chemical techniques and the experimental identification of atomic weights were definitely within her capabilities. Eventually taking advantage of her chemical expertise, Horovitz joined Hönigschmid in determining the atomic weight of lead from St. Joachimstal pitchblende. As Hönigschmid reported to Meitner in June 1914, "Miss Horovitz and I worked like coolies. On this beautiful Sunday we are still sitting in the laboratory at 6 o'clock."[130] Conscious of the importance of their work,

[126] Badash, "The Suicidal Success of Radiochemistry," (1979), pp. 250.
[127] Sabine, "Lise Meitner an Otto Hahn" (1992), p.149. The original letter from Meitner to Hönigschmid, January 26, 1914, is deposited at the Churchill College Archives, Cambridge University, MTNR 5/78.
[128] Rayner-Canham, M. and Rayner-Canham, G. "Stefanie Horovitz," (1997), p. 194.
[129] Bischof, *Frauen am Wiener Institut,* (2000), p. 62.
[130] Rayner-Canham, M. and Rayner-Canham, G. "Stefanie Horovitz," (1997), p. 194.

they immediately sent their article first to the *Monatshefte für Chemie* instead of the Institute's *Mitteilungen* and shortly afterwards they published a version in the French *Comptes Rendus.*[131] Hönigschmid and Horovitz offered the most convincing confirmation of the existence of isotopes and for the next two years they continued to co-publish on the atomic weights of uranium, thorium and ionium.[132] Their research showed that ionium was not a separate element but just an isotope of thorium. Another woman, Bertha Heimann, had already probed the lifespan of thorium and published her work at the *Mitteilungen* in 1914.[133]

The end of the First World War brought also an end to the Hönigschmid-Horovitz collaboration. He accepted a position at the University of Munich and she left the Institute to return to her hometown in Poland. Long afterwards, Kasimir Fajans informed Elisabeth Rona, one of the women who worked at the Institute in the 1920s, "Stefanie moved there [to Warzawa] to join her married sister after World War I after her parents had died in Vienna. She was not active in chemistry and she and her sister were liquidated by the Nazis in 1940."[134] Hönigschmid committed suicide near the end of the Second World War unable to bear the burdens imposed by the Nazis.[135]

Historically, the significance of Hönigschmid-Horovitz collaboration is that stereotypical gender narratives cannot capture its dynamic. On the one hand, Lawrence Badash, accepting the image of women as students, assistants, and weak partners in scientific collaborations, arbitrarily assumes that Horovitz was Hönigschmid's student.[136] On the other hand Marelene and Geoffrey Rayner-Canham, seduced by their own attempt to emphasize the unfair interpretation of Horovitz's contributions, attribute the main research to her, forgetting Hönigschmid's role by referring to 'her results" when they actually site co-published papers.[137] Interestingly enough, they repeat Badash's assumption that Horovitz was Hönigschmid's research

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[131] Hönigschmid and Horovitz, "Über das Atomgewicht des 'Uranbleis'," (1914), pp. 1557-1560; Hönigschmid and Horovitz, "Sur le poids atomique du plomb de la pechplende," (1914), pp. 1796-1798; Hönigschmid and Horovitz, "Über des Atomgewichtes des 'Uranbleis,'" (1914), pp. 2407-2432.

[132] Hönigschmid and Horovitz, "Über des Atomgewichtes des 'Uranbleis II," (1915), pp. 335-380; Hönigschmid and Horovitz, "Zur Kenntnis des Atomgewichtes," (1915), pp. 1089-1094; Hönigschmid and Horovitz, "Revision des Atomgewichtes des Thoriums," (1915), pp. 149-178; Hönigschmid and Horovitz, "Zur kenntnis des Atomgewichtes des Ioniums," (1916), pp. 179-199.

[133] Heimann, "Über die Lebensdauer des Thoriums," (1914).

[134] Fajans to Rona, August 31, 1963, BHL.

[135] Rayner-Canham, M. and Rayner-Canham, G., "Stefanie Horovitz," (1997), p. 195.

[136] Badash, "The Suicidal Success of Radiochemistry," (1979), p. 252.

[137] Rayner-Canham, M. and Rayner-Canham, G., "Stefanie Horovitz," (1997), p. 194.

student instead of being young, probably inexperienced, but nevertheless independent chemist.[138] In their descriptions of Horovitz's assigned tasks, the Rayner-Canhams employ expressions such as "time-consuming" and "demanding procedures." Thus they imply that she played a secondary role by carrying routine assignments in the laboratory. However, as Hönigschmid clearly stated in his aforementioned letter to Meitner, they both worked hard in the laboratory. On the one hand, as the more mature partner and deeply involved in radioactivity, he was the one who introduced Horovitz to working with radioactive elements, welcoming her in the Institute. On the other hand, she was the one who carried over her chemical expertise from the Chemistry Institute to the neighboring Institute for Radium Research and entered the field of radioactivity as a traditional chemist and young researcher.

If Horovitz's involvement in radioactivity research serves as a clear example of women's entrance to the field because of the essential interplay of chemistry and physics, the case of Marietta Blau brings front and center the significance of medicine and clinical radiotherapy to radiophysics. Blau enrolled at the University of Vienna in 1914 and chose physics as her major and mathematics as her minor. For her *Praktikum* she worked for two semesters in Exner's Institute and one in the Institute for Radium Research.[139] In 1918 she first appeared as an author in the *Mitteilungen* of the Radium Institute.[140] She had just submitted her dissertation "on a radiological subject," the absorption of diverging gamma rays, at the second Physics Institute (Exner's Institute).[141] Her research topic turned out to be important for clinical treatments of cancer. Discovered by a French physicist, Paul Villard, gamma rays occupied the interest of the radioactivity community from 1900. In 1904, Marie Curie performed the first gamma radiography and in 1914 Rutherford showed that gamma rays were a form of electromagnetic light.[142] Because of their penetrating power, which is much higher than that of x-rays, the gamma rays proved to be crucial in killing cancerous cells. Eventually it was Blau's radiological research topic that opened the door of Holzknecht's radiological Institute for her. After defending her thesis in 1919, as Blau put it in a later curriculum vitae, "I conducted theoretical

[138] Rayner-Canham, M. and Rayner-Canham, G. "Stefanie Horovitz, Ellen Gleditsch," (2000), p. 104.
[139] Marietta Blau, Curriculum Vitae, July 4, 1918, Rigorosenakt 4557, AUW.
[140] Blau, "Absorption divergenter Gamma-Strahlung" (1918), pp. 1253-1279.
[141] Blau, self description, Curriculum Vitae, July 4, 1918. Rigorosenakt 4557. AUW.
[142] Gerward and Rassat, "Le decouverte des rayons gamma" (2000), pp. 965-973

studies and at the same time was a research assistant at the Laboratory for Medical Radiology at the Holzknecht Clinic, where I studied Medical Physics."[143] Blau's case indicate that the physical proximity of the Institute to the *Allgemeine Krankenhaus* in the *Mediziner-Viertel* played a significant role in facilitating the literal travel of radium and the transferring of personnel from Boltzmangasse to the neighboring medical facilities.[144] For instance, Meyer helped the physician Gustav Riehl set up the Radium Station of the *Allgemeine Krankenhaus* and provided the expertise of his colleagues for the preparation of radium for therapeutic use.[145] Available to all the clinics and departments of the hospital, the Radium Station, together with Holzknecht's Röntgen Laboratory, provided a network of medical practitioners to the Institute for Radium Research. It was Blau who took advantage of these connections in order to maintain her work on radioactivity.

Unlike Souczek, Friedemann, and Horovitz, Blau hovered at the boundary of medicine and physics for the rest of her career. In 1921 Blau left Vienna to accept a position in a company that manufactured x-ray tubes in Berlin. Later on she worked as a research assistant at the Institute of Medical Physics in Frankfurt am Main.[146] For two years Blau did her own research and instructed doctors in radiobiology while she "conceived and elaborated a theory on the effect of x-rays on biological objects."[147] As Galison has shown, "The border zone between medicine and physics brought Blau much nearer the realm of nuclear physics than it may at first appear."[148] In her later work on photographic emulsions one can clearly trace the transfer of knowledge, techniques, and instruments from one discipline to the other.

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[143] Marietta Blau, Curriculum Vitae, 1941, GDSCA.
[144] The Institute for Radium Research acted as the official provider of radium preparations. Both Stefan Meyer and Friedrich Paneth played an important role in providing the Viennese hospitals with radium for medical use (Meyer, "Das erste Jahrzehnt," (1920), p.12; Meyer, "Die Vorgeschichte," (1950), p. 20; Protokoll Z 8167, 30 November 1911, AÖAW).
[145] Meyer to Riehl, June 7, 1912, AÖAW. The Radium Station was equipped with radium plaques of different shapes, with Dominici tubes, and Wickham apparatuses. The Dominici tubes were used for endocavitary treatments (Tubiana, Dutreix, and Pierquin, "One Century of Radiotherapy," (1996), pp. 231-232). The Wickham apparatuses were gynecological applicators designed to be inserted into the uterus for the treatment of cancer (Mould, *A Century of x-rays,* (1993), p. 134.)
[146] Galison, "Marietta Blau," (1997), p. 42.
[147] Marietta Blau, Curriculum Vitae, 1941, GDSCA. As Richard Beyler suggests, the Frankfurt Institute was the epicenter of target theory in Germany. The theory's aim was to use radiation to probe the structure of the organic. Blau played an instrumental role in developing the statistical analysis of radiation biology, the main research project of Friedrich Dessauer, the director of the institute. (Beyler, "Imagine a Cube," (1997), pp. 39-46).
[148] Galison, *Image and Logic,* (1997), p. 149.

In the transition years at the end of the First World War, three more women appeared in the Viennese scene of radioactivity research. In the 1919 edition of the *Mitteilungen,* Eleonore Albrecht pursued further work on isotopes, specifically on the C´´ products of the three decay chains of the radioactive series of radium, actinium, and thorium.[149] With her observations on the C´´ products of radium, Albrecht demonstrated a phenomenon described by Robert Lawson in the same edition of the *Mitteilungen*.[150]

Grete Richter focused on discrepancies between theoretical and experimental results in Mache's and Ludwig Flamm's study of saturation current produced by radium F, a descendant of uranium series.[151] Saturation was much more difficult to attain for alpha rays than for more penetrating radiation. Hilde Fonovits embarked on a detailed investigation of the factors necessary to obtain alpha ray saturation.[152] Although Albrecht and Richter did not continue their research, Fonovits stayed at the Institute as an unpaid assistant from 1 December 1919 to 30 November 1920.[153] Friedrich Paneth, Meyer's second assistant, had already accepted the position of an *Extraordinarius* (associate professor) at the University of Hamburg in 1919 and temporarily K. Herzfeld took over his tasks for a short period of time.[154] This same position was apparently Fonovits' chance to remain at the Institute. In December 1920 she was formally accepted as *ausserordentliche Assistentin* with a monthly salary of 1000 Kronen.[155] In the meantime Fonovits got married and when in 1922 her son, Robert Smereker, was born she quit her job.

At first sight, Fonovits's story seems rather stereotypical. Putting up with an unpaid research position, she eventually withdrew from a scientific career because of family commitments. As the common myth runs, women scarcely succeed in

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149 Albrecht, "Über die Verweigungsverhältnisse," (1919), pp. 925-944. For an explanation of the chemical symbols see the main decay chains of the four radioactive series in the appendix. Historical names, such as RaC, AcC, and ThC, are shown on the diagram and the accepted chemical symbols appear on the axis.

150 Lawson, "Der Aggregatrückstoß" (1920), p. 795-830; It first appeared at the *Mitteilungen*, article no. 118. The phenomenon was termed "aggregated recoil" and described the fact that when polonium was deposited by electrolysis on a clean metal foil, surrounding objects became active as well.

151 Richter, "Messungen im Schutzringplattenkondensator," (1919), pp. 539-569. See the appendix for the historical names of uranium series.

152 Fonovits, "Über die Erreichung," (1919), p. 761-793.

153 Bischof, *Frauen am Wiener Institut,* (2000), p. 66.

154 Ruthenberg, "Friedrich Adolf Paneth," (1997), pp. 103-106; Meyer, "Die Vorgeschichte," (1950), p. 26.

obtaining both. However, her later life and career as a director of the Radium Station at the Lainz Hospital in Vienna contradicts any stereotypical gender assumptions. Fonovits' second involvement in radioactivity research in the early 1930s came through a different route, that of medicine and radium dosimetry, underpinning the idea that radium as a boundary object offered women a chance to take advantage of the interdisciplinarity of the field.

3.4. Radioactivity as a Trading Zone

After its discovery, radium entered the world as an object eagerly shared by many social worlds and diverse scientific communities. Boundary objects inhabit trading zones; radium entered mainly into a trade among physics, chemistry, and medicine, although it was later shared by a number of other scientific disciplines. Lawrence Badash points out that "radioactivity was something of a hybrid between physics and chemistry" with its data coming from an impressively diverse number of scientific disciplines.[156] Jeffrey Hughes, tracing the changing cultures of theory in nuclear science from 1920 to 1930, similarly argues that "in a field [radioactivity] which drew its practitioners from such a wide range of backgrounds, including chemistry, physics, geology and medicine, the variety of interpretative practices was unusually large."[157] Earlier on, Marjory Malley, illustrated how these different interpretative practices and diverse scientific styles led to a different interpretation of the transmutation phenomena, specifically for the case of the Curies and Rutherford.[158] In a recent study, Arne Hessenbruch traces the connections of radioactivity to technology by focusing on Rutherford's 1901 experiment on radiation energy. As Hessenbruch wonders, "who precisely were the many different

[155] Meyer to the Professorenkollegium der Philosophischen Fakultät der Universität, October 27, 1920, AÖAW.
[156] Badash, "The Suicidal Success of Radiochemistry," (1979), p. 253. In this paper Badash traces the history of radiochemistry by focusing on the collaboration of chemists and physicists in their early efforts to identify the radioactive elements. As he claims, by the early 1920s and since all the radioelements were known, there were no more opportunities for basic research in radiochemistry. As I suggest, this early collaboration of physicists and chemists forced them in an interdependent relation that was carried over in the next two decades of radioactivity research.
[157] Hughes, "Modernists with a Vengeance," (1998), p. 342.
[158] Malley, "The Discovery of Atomic Transmutation," (1979), pp. 213-223.

constituencies and individuals involved in the early history of radioactivity? There were physicists, chemists, and medics, each having a different perspective."[159]

However, as it turned out, the cultures engaged in constant trade of radium were not only scientific ones. While scientists treated radium as an object for research, industrialists, bankers, and entrepreneurs saw in radium an invaluable source of financial success. Physicists found themselves in endless negotiations with financial administrators. In some cases the interactions between distinct cultures led them to get involved in radium industries as an essential move for their scientific agenda.[160] Shortly after its discovery, the price of radium became astronomically high, partly because the principal source, the Austrian mines, produced it in such limited quantity. When the Austrian government placed an embargo on the export of pitchblende ore, physicists, physicians, bankers, and industrialists searched desperately for new sources of the valuable element. In 1912 *The New York Times* reported that "as the result of the investigation of Henry Chagneux, an expert in radio-active minerals, who is in Meeker [Colorado] on behalf of Mme. Curie, discoverer of radium, and the Bank of Radium of Paris, negotiations have been completed for the purchase of the largest carnotite deposits in the country."[161] In 1913 European capitalists planned to form a large corporation for the monopoly of radium throughout the world. The capital for the company was estimated at $3,750,000, and one of the promoters was Baron Geza Radivanski, Director of the Hungarian National Bank.[162] At the same time there was a forceful debate over the role of governmental control of radium deposits in the United States. In 1914 this became an issue in one of Rutherford's letters to Meyer: "they [companies who were separating radium from carnotite ore] have been trying to pass a law that all radium mines should be sold to the Government and hope in this way to prevent the large exportation of ore."[163]

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[159] Hessenbruch, "Rutherford's 1901 Experiment," (2000), p. 419.

[160] For the case of Curie's laboratory and the connections to industry see Roque, "Marie Curie and the Radium Industry," (1997), pp. 267-291; Boudia, "The Curie Laboratory," (1997), 249-265. Curie tried hard to secure industrial resources and radium supplies by collaborating with the French radium industry and maintaining the technical character of her earlier work at the *Ecole Superieuer de Physique et Chimie Industrielles*. Yet, the Austrians had control over the Bohemian mines and easily secured radium for their research.

[161] "Seeks Radium in Colorado," in *The New York Times*, September 12 1912, 1:6.

[162] "Plan to Corner World's Radium," in *The New York Times*, October 6, 1913, 3:2.

[163] Rutherford to Meyer, May 11, 1914, Rutherford Papers, CUL. On the same debate see also "Dr. Douglas Fears Radium Monopoly," in *The New York Times*, December 20, 1913, 18:1; "Two Routes to One Destination," in *The New York Times*, December 20, 1913, 12:4; "U.S. to Conserve Radium Deposits," in *The New York Times*, January 15, 1914, 2:5.

Doctors, too, invested in radium because of its great promise in medicine and for curing cancer. Once more Rutherford was worried. As he wrote to Meyer: "I hope you will be able to reserve a large quantity for experimental purposes, otherwise I am afraid it will all go into the doctors' hands."[164]

Not surprisingly, during the early years of its discovery radium became a symbol of power and wealth. As Meyer informed Rutherford, "We have of course a big competitor in the King of England who through personal intervention of our Kaiser has assured for himself personally, ahead of anyone else, a whole gram of pure radium from the material coming from the factory."[165] Strangely enough, radium was also presented as an object worthy for display to the public. In 1914 two grams of were on display for a week at the Public Health Exposition in Grand Central Palace, New York. Hamilton Foley, an employee of the Radium Chemical Company, made the demonstration. Medical students, physicians, nurses as well as the curious public were invited to see the exhibition. State police placed the radium under high security.

The outbreak of the First World War elevated radium to an essential 'weapon' of warfare. Several devices of the airplanes that flew over enemy camps such as speedometers, compasses, barometers, inclinometers and dashboard instruments had luminescent dials made by radium paint. A number of industries for dial painting were established in France and the United States, which after the dramatic deaths of their employees, all women dial painters, led to further medical research in clinical radiotherapy and the establishment for radium safety standards.[166] By the end of the First World War radioactivity was a mature and prestigious field, with a number of Nobel prizes and at least four serious research centers in Europe: the Institut du Radium in Paris, Rutherford's laboratory in Manchester, the Kaiser Wilhelm Institute for Chemistry in Berlin under Otto Hahn and Lise Meitner, and the Institute for Radium Research in Vienna.

Since the time of the Institute's establishment the identity of the Viennese physicists shifted from radium merchants to prominent experimenters. Arguments that treat research in radioactivity as involving tedious tasks and routine work responsible for driving men away do not reflect the resounding successes during the 1910s. For

[164] Rutherford to Meyer, October 22, 1910 in Rutherford Papers, CUL.
[165] Meyer to Rutherford, April 28, 1912 Rutherford Papers, CUL.
[166] Rentetzi, "The Women Dial Painters as Experimental Subjects," (forthcoming).

example, in 1912 Hess discovered cosmic radiation based on his work at the Vienna Institute, a discovery that led to a Nobel Prizes in 1936. During 1912 and 1913 Fritz Paneth and Georg von Hevesy conducted research that led to the discovery of the radioactive-tracer technique and Otto Hönigschmid produced the first radium standard.[167] As the field matured, women entered the Radium Institute in larger numbers. The specific data about their entry into radioactivity research in Vienna undermine the argument that their proportion dwindled as the field became more attractive to men.[168] Despite the difficulties, women moved even to the upper ranks within the Institute, obtaining such high positions as that of an *Assistent*.

Following radium's trajectories, one can trace the pathways by which women came into the prestigious field and by which they altered the boundaries of their own emerging discipline. In the Viennese scene, the space of trading and exchange was as tangible as the radium itself. The *Mediziner-Viertel* hosted physics and chemistry research institutes, medical clinics, and radium entrepreneurs. Unique in the scientific world of the time, it functioned as an *in vivo* laboratory for scientific, cultural, political, and artistic experiments. Within this context women formed their professional identities as physicists specialized in radioactivity and gained the respect of their colleagues. After all, as a trading zone, radioactivity offered them multiple passages for entrance and several opportunities for surviving in it as researchers.

[167] Reiter, "Vienna: A Random Walk" (2001), pp. 476-77.
[168] Rayner-Canham, M. and Rayner-Canham, G. *Harriet Brooks,* (1992), p. 106.

CHAPTER 4
GENDER AND THE ARCHITECTURE OF THE INSTITUTE FOR RADIUM RESEARCH

Although historians of science have taken a great interest in the laboratory as a space of scientific practice, they have paid less attention to the architecture of the laboratory.[1] Sophie Forgan points out, that historians have presented scientists as deeply concerned with merely the functional side of their laboratories and the architecture of the laboratory as an external factor to the science produced within its walls.[2] As Peter Galison and Caroline Jones emphasize, nonetheless, "the architecture, social structure and cultural siting of laboratories matters; it matters to the character of the science produced, it matters to the shifting definition of what counts as experimentation and who counts as an experimenter."[3] The myth of scientists' indifference to the architecture of their laboratories literary blocked any research on this direction.

The heroic portrayal of the male scientist as absolutely absorbed by his equations, abstract theories, and complex scientific instruments, forgotten in an obscure laboratory, haunted historians for years. The autobiographies, especially of physicists, as Sharon Traweek points out, enforce the above stereotype and create a popular image of scientists as socially inept.[4] As the myth runs, scientists are deeply involved in their science, condemned to their experimental settings and laboratory instruments, absolutely oblivious to their surroundings. The external appearance and the internal configurations of laboratory buildings are of no concern to them at all. Rather, these are said to occupy the interest of the architects or the generous patrons

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[1] In the recent years the literature on the architecture of science has grown rapidly. The following are a few sources for further reference. Forgan, "Context, Image and Function," (1986), pp. 83-113; Forgan, "The Architecture of Science," (1989), pp. 405-434; Forgan, "The Architecture of Display," (1994), pp. 139-162; Forgan, "Bricks and Bones," (1999), pp. 181-208; Forgan and Gooday, "Constructing South Kensington," (1996), pp. 435-468; Cahan, "The Geopolitics and Architectural Design," (1989), pp. 137-154; Pratt, "Design of a Biomedical Laboratory Building, Part I and Part II," (1985), pp. 141-143 and pp. 179-181; Hannaway, "Laboratory Design and the Aim of Science," (1986), pp. 585-610; Shackelford, "Tycho Brahe, Laboratory Design," (1993), pp. 211-230; James, "Expressionism, Relativity, and the Einstein Power," (1994), pp. 392-413; Latour, "Mixing Humans and Nonhumans Together," (1995), pp. 257-280; Obrist and Vanderlinden, *Laboratorium*, (1999); Galison and Thomson, *The Architecture of Science* (1999); Knowles and Leslie, "'Industrial Versailles'," (2001), 92:1-33. Hoffmann, "The Design of Disturbance," (2002), pp. 173-195.

[2] Forgan, "The Architecture of Science," (1989), p. 405-434.

[3] Galison and Jones, "Trajectories of Production," (1999), p. 205.

who seek to boost their prestige by funding the splendid architecture of science buildings.

On the contrary, as I have argued in chapter 2, Viennese physicists and chemists were intimately concerned with the design and architectural style of their institutes. In the early 1870s it was natural scientists who objected to the splendid Renaissance architecture of the new Chemistry Institute at Währingerstrasse 10, as incompatible with the austere character of their science. And again, when the architect Heinrich von Ferstel was assigned to design the university quarter and include a chemistry and physics institute, he closely cooperated with their directors, Josef Redtenbacher and Josef Stefan, in order to accommodate the needs of the scientists. The architect of the most significant natural science buildings of *fin-de-siècle* Vienna, Ferstel, drew up the plans of the institutes. Yet, it was always the director who informed him about the peculiarities of the science for which Ferstel planned.[5] In 1909 when the complex of the Physics, Chemistry, and Radium Institutes was finally designed at the triangle of Boltzmanngasse, Währingerstrasse, and Strudelhofgasse, it was only with the help of the directors that the architects were able to deal with the many different research specialties.[6] And it was only with the agreement of the director and the Academy, and after their demands for a quieter spot for their institutes that the state provided the above mentioned triangle to the architects.

Interestingly, the indifference of scientists to the architecture of their laboratories has its roots also in the negative reaction to social constructivism by traditional historians. Advocates of the purity of science and its independence from social factors excluded architecture from the historiography of science. Internal intellectual history, especially in the case of physics, left the architecture of the laboratory out of its scope as irrelevant to its project. Thus, awareness of the spatial character of the laboratory and its architecture is a relatively recent phenomenon and not widespread among historians of science. Forgan, focusing on the architecture of science in Victorian England, stresses the fact that buildings carry messages of

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[4] Traweek, “Iconic Devices,” (1997), p. 103.

[5] Besides the plans for the physics institute, which were never realized, and the design of the chemistry institute, in 1872 Ferstel designed the meteorological station at Hohe Warte 38, in the 19th district of Vienna (Reiter, “Vienna: A Random Walk,” (2001), p. 484).

[6] Golitschek and Elbwart, *Der Neubau des Physikalischen Institutes,* (1915), p. 1.

importance and authority while they constrain the formation of scientific disciplines.[7] Discussing the architecture of the *Physikalisch-Technische Reichsanstalt* in Berlin, David Cahan illustrates how the choice of architectural style and site conveyed the message of the German leadership in physics.[8] In a more recent article, Christoph Hoffmann emphasizes the constructive role of architecture in science buildings by focusing on disturbances as inevitably interfering with “the inside of science.”[9] Similarly, the collection of articles edited by Galison and Emily Thomson sheds a different light on the relationship between science and its buildings. The changes in the architecture of scientific sites, traced through time, reveal that changes in spatial arrangements configure the scientific process in a number of dimensions and vice versa. In this chapter I trace the ways the laboratory space is gendered and what this has to do with the science produced within the walls of the laboratory.

4.1. The Urban Setting of the Institute.

At the beginning of 1909, with a generous donation from Kupelweiser, Meyer and Exner worked on the *Raumprogram*, the space program of the building at a frenzied pace. They soon provided *Frauenfeld and Berghof*, a Viennese architectural firm, with a sketch of the complex of the Physics, Chemistry, and Radium Institutes.[10] The proposed location was a spacious state property of 12,065 square meters across from the *Josephinum* known as *Bäckenhäusel*.[11] Historically, the building belonged to a baker in the 15th century, and from 1648 to 1784 it served as a small hospital. Later on it was converted into a residential building. Just before physicists decided to build their institute at this spot, the building hosted a tobacco administration and storeroom.[12] After tearing down the old *Bäckenhäusel,* a complex of three buildings went up in its place. The quietest corner of Währingerstrasse and Strudlhofgasse was chosen to host the Physics Institute. On the corner of Währingerstrasse and

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[7] Forgan, “Context, Image, and Function,” (1986), pp. 83-113; Forgan, “The Architecture of Science” (1989), pp. 405-434; Forgan, “The Architecture of Display,” (1994), pp. 139-162; Forgan, “Bricks and Bones,” (1999), pp. 181-208.

[8] Cahan, “The Geopolitics and Architectural Design,” (1989), pp. 137-154.

[9] Hoffmann, “The Design of Disturbance,” (2002), p. 189.

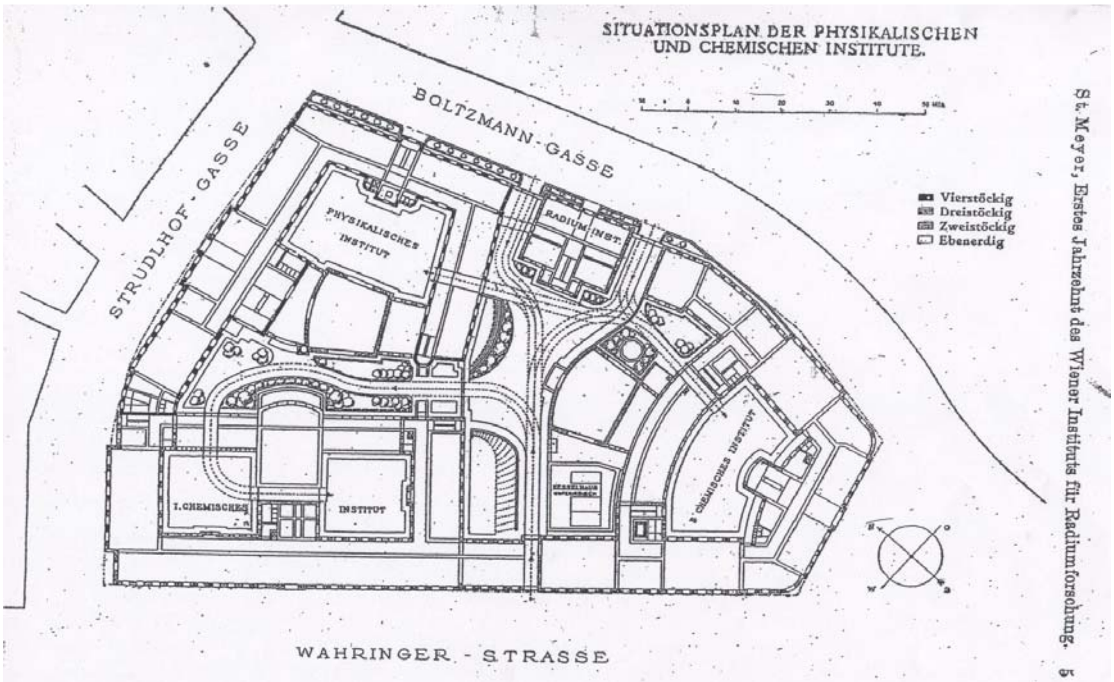
[10] Meyer, “Das erste Jahrzehnt,” (1920), p. 3

[11] Hittner, *Geschichte des Studienfaches Physik,* (1949), p. 73.

[12] Schönfeld and Ipser, “Die Geschichte der Chemie,” (2000), p. 22.

Boltzmanngasse the chemists designed their own facilities. The Radium Institute was then located between the two buildings, facing Boltzmangasse.

Figure 4.1 The architectural plans of the natural science quarter (source: Meyer, Stefan. 1920. "Das erste Jahrzehnt des Wiener Instituts für Radiumforschung" *Jahrbuch der Radioactivität und Electronik* XVII Band, Heft 1, pp. 1-29).



As the Institute was pursuing research on radium, a boundary object shared between chemists and physicists, its architectural structure reflected the existence of a closely interrelated community of natural scientists. A bridge on the level of the third floor connected the Physics to the Radium Institute. As Meyer strikingly described, "the bridge to the physics institute was not only a material connection but also an ideal one; friendly relationships with the neighboring institute were necessities of life."[13] The contact was crucial for both sides. The Physics Institute was equipped with a big library and experimental apparatus that the Radium Institute lacked. A non-contaminated room for reliable measurements was also available at the Physics

[13] Meyer, "Das erstes Jahrzehnt," (1920), p. 6 (translation mine).

Institute. Evidently, Hans Pettersson and his group, working on artificial disintegration in the 1920s at the Radium Institute, used the facilities that the neighboring institutes offered to them. In his formal report to the International Educational Board in 1928 Pettersson emphasized that:

> as these investigations must necessarily be divided into one 'contaminated' and one 'un-contaminated' part, the first for preparing and measuring the intense radioactive sources, the second for detecting their extremely minute effects in the shape of the rare atomic fragments, the work should not have been possible, had not the Radium Institute happened to be in such close and excellent cooperation with the adjacent I and II Phys. Institutes, the directors of which have also put a considerable part of their apartments and equipment at our disposal.[14]

Besides the material benefits, the bridge offered to the science practitioners in both institutes the opportunity to exchange ideas and to learn about the latest research of their colleagues. In some sense it made tangible their elusive feeling of belonging to the same physics community and gave stability to certain collaborations. Exner, although director of the second Physics Institute, was also the official director of the Radium Institute. It was this double belonging that the bridge materialized for him and his colleagues. On the other side the propinquity of the Chemistry Institute was essential, for it provided the possibility of collaboration among physicists and chemists, and yet tangibly maintained the boundaries of their disciplines rigid.

Additionally, the proximity of the Radium Institute to the *Technische Hohschule* made advanced studies that suited the needs of the research personnel easily available. For example, Friderike Friedmann took advantage of courses, offered in electrotechnique at the *Technische Hohschule*. Besides serving as a source of further training, the *Technische Hohschule* functioned as a possible source of employment as well. It was Dagmar Pettersson who got a position as laboratory assistant at the *Technische Hochschule* after her arrival to Vienna in 1922.[15]

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[14] Hans Pettersson's report to the International Education Board, Part III, April 1928, GUB (in English). The International Education Board (IEB) was founded in January 1923 by John D. Rockefeller, Jr. Its aim was to promote the natural sciences by granting fellowships to a number of individuals and institutes throughout Europe. It was most active between 1923 and 1928. In 1929, given the reorganization of the Rockefeller Foundation, the IEB was merged with it and finally dissolved in December 1938 (see http://www.rockefeller.edu/archive.ctr/rf.html last checked 3/31/2003).

[15] Dagmar mentioned this to a letter to Otto Pettersson on December 12, 1922. On October 29, 2001, her daughter, Agnes Rodhe, conveyed the information to the author. It is surprising that although the *Technische Hochschule* had just opened its doors to women as matriculated students in the winter

The point here is that the proximity of science institutes located in the *Mediziner-Viertel* mattered seriously to the science produced and the scientists involved in its production. First of all, within the boundaries of the *Viertel* personal communication took place that facilitated interdisciplinary exchanges. Along with the flow of ideas there was a reciprocal flow of people across Währingerstrasse and within the institutes. The few women in science became visible, a fact that helped them to become surprisingly well integrated within the Viennese scientific community. Second, the architectural interconnectedness of science buildings provided a sense of stability and durability of collaborations to the scientists of the *Viertel*. Hosting a boundary object, the Institute for Radium Research and its scientists depended on interdisciplinary collaborations and, thus, were in need of stable routes of scientific exchanges.

Finally, the proximity of the natural sciences quarter to the *Josephinum* and the hospitals was also convenient for both natural scientists and physicians. Apparently the network of support was mutual. The physicists offered lectures on experimental physics to medical students and the chemists gave courses on experimental chemistry for the pharmaceutical students. Courses on the theory of the microscope, inorganic chemistry, and theoretical and physical chemistry were highly attended by medical students.[16] Medical doctors urgently needed radium supplies and measurements of radium preparations for clinical uses and the physicists were glad to use the spent radon needles received from hospitals for polonium preparations.[17] Interesting collaborations came up when researchers crossed Währingerstrasse literally carrying instruments and laboratory materials to the neighboring institutes. For example, Elisabeth Rona, from the Radium Institute, and Goldschmidt from the Physiological Institute studied the use of polonium in the cure of leukemia.[18] The

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semester of 1919/20, Dagmar was able to obtain the position of *Assistentin* in 1922 (Bischof, *Frauen am Wiener Institut* (2000), p. 62). It was probably dew to Meyer's strong connections and the fame of the Radium Institute that she was able to do so.

[16] For example, in 1910 Ernst Lecher taught experimental physics for medical students and a year later he published one of the first textbooks on physics for physicians and biologists (Schweidler, "Bericht des Generalsekretärs" (1927), p. 178). Egon Schweidler offered a course on experimental physics for pharmaceutical students and Felix Ehrenhaft lectured on the theory of microscope. The same year the chemist Skraup Zdenko taught inorganic chemistry for pharmaceutical students and the chemist Josef Herzig offered pharmaceutical chemistry (Vorlesungen an der k.k. Universitat zu Wien, 1910-1911, AÖAW).

[17] Rona, *How it Came About,* (1978), p. 22.

[18] Meyer, "Die Vorgeschichte," (1950), p. 20.

research personnel found it convenient to "keep in touch," keeping at the same time the autonomy of their research facilities. It was probably this that Kupelweiser had in his mind when he explicitly set the condition that the Radium Institute should be exclusively for physics and not medical research.[19]

Yet the urban setting of the Institute in the *Mediziner-Viertel* tells us something more. It reminds us that physicists and medical practitioners were more and more in a mutually dependent relation. In the process of organizing the second Congress on Radiology and Electricity, Rutherford admitted to Meyer that "we have very few medical representatives in the list, and this is invidious."[20] This was a deplorable situation given that, in most European countries and in a few cities in the United States, hospitals were already incorporating radium stations in their facilities.[21] In Manchester, Rutherford's own city of residence, William Milligan an otolaryngologist, established a radium laboratory at the Manchester Royal Infirmary. Rutherford was asked to offer his advice on radium sources while his laboratory monitored the radium supplies and their quality for the newly established medical facility.[22] Physicians needed radium standards for their medical work as much as physicists wanted them for their research.[23] On the one hand, the Viennese had a strong tradition in medicine and, on the other hand, physicists were deeply interested in the medical applications of their research. They eventually succeeded in espousing both in the urban setting of the Radium Institute. The map of the *Mediziner-Viertel* reflected the same modes of scientific collaboration as the list of the committee members of the Radiology and Electricity Congress. It is not surprising that the proposed representatives from Vienna, besides the physicists of the Radium Institute, included the radiologists Guido Holzknecht, the roentgenologist Robert Kienböck, the director of the Radium Station in the Viennese General Hospital Gustav Riehl, the pharmacologist at the Medical Faculty of the University of Vienna Knaffl-Lenz, and the physician Hans Horst Meyer.[24] On June 29, 1914, while Rutherford was arranging

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[19] Kupwlweiser to the Academy of Sciences, August 2, 1908, AÖAW.
[20] Rutherford to Meyer, June 1, 1914, AÖAW.
[21] See also Badash, *Radioactivity in America*, (1979), p. 132-4.
[22] Fox, "The History of Radium," (1998), pp. 115-124.
[23] See for example Rutherford to Meyer, November 18, 1911, CUL; Meyer to Rutherford, December 16, 1913, CUL; Rutherford to Meyer, January 14, 1914, CUL; Meyer to Rutherford, February 9, 1914, CUL. Rutherford to Meyer, June 29, 1914, AÖAW.
[24] Meyer to Rutherford, December 5, 1913, CUL; Meyer to Rutherford, December 16, 1913, CUL.

the last details for the meeting, he did not anticipate the outbreak of the First World War in August 1914.[25]

4.2. New Kinds of Disturbances: From Noise and Vibrations to Radium Contamination and Hazards

Before the physicists and their patron decided on the location across from the *Josephinum,* two other sites were under consideration for the natural science quarter. One was located on Währingerstrasse, where the *Volksoper* was finally built, and the second one was the old *Gewehrfabric*, the gun factory at the corner of Währingerstrasse and Schwarzspanierstrasse where in 1904 the Institute for Physiology was established. All of them were located within the *Mediziner-Viertel,* based on the self-evident assumption that the new institutes should be very close to the center of the city and within the university quarter.[26] The two locations, however, seemed insufficient for a Physics Institute. At Währingerstrasse the traffic was heavy with electric streetcars passing constantly in front of both proposed locations. Physicists were very concerned about the disturbing noises and vibrations. As Hoffmann argues the case in Germany, "An ordinary physics institute at the end of the nineteenth century embodies in bricks and mortar, stone and lime precisely this command: Disturbances have to be avoided."[27]

The concern about disturbance, nevertheless, was not a German peculiarity. Austrian physicists were also uneasy with the traffic on Währingerstrasse and the external factors that would interfere with their attempts to measure precisely radium preparations or to perform spectroscopic analysis. The stability of their installations had always been important. When the Institute was still at Türkenstrasse, the physicists' main complaint was the shaking of the floor and the disturbances of vibrations. "Whenever in the neighboring house someone was ironing," Benndorf recalled "the needle of the magnet was going here and there and we were in such a nasty position several times."[28] To the physicist it was out of the question to put up

[25] Rutherford to Meyer, June 29, 1914, AÖAW.
[26] Golitschek and Eldwart, *Der Neubau des Physikalischen Instituten,* (1915), p. 1.
[27] Hoffmann, "The Design of Disturbance," (2002), p. 174.
[28] Benndorf, "Gedenkrede auf Franz Serafin Exner aus Anlass der Enthullung seines Denkmals in der Universitat Wien am 23 Janner 1937," p. 7, Nachlass Exner, AÖAW (translation mine).

with a similar situation in the new location. The experience of the *Physikalisch-Technische Reichsanstalt* in Berlin made Austrians suspicious of any disturbances.[29] At the end of 1900s the city's street company decided to lay electrical streetcar tracks in front of the *Reichsanstalt*, which ended up interfering with the electric and magnetic research at the institute.

Viennese physicists refused to take the first proposed site, since it was too close to the street. Furthermore, the second proposed site, the one at the old *Gewehrfabric,* was next to the Anatomical Institute, which was equipped with high voltage current. The induction current it generated, affected the function of their electromagnetic apparatus, which made the research of the physicists impossible.[30] Thus in order to control vibrations, noise, and electromagnetic disturbances, Viennese physicists chose the *Bäckenhäusel* as the quietest location, one that could create a less destructive environment for research. Traffic was redirected further away from the new building by adding an extra lane on both sides of the street. Instead of passing close to the Institute's building, the streetcars drove in the middle lane of Währingerstrasse. This way, mechanical vibrations through the ground were eliminated. Additionally, trees on the sidewalk in front of the buildings and inner courtyards protected the small natural sciences quarter from disturbances coming from the street.[31] Locating the Radium Institute between the Chemistry and Physics Institutes, Exner and Meyer aimed to eliminate further the interference of external factors with scientific work. Physicists and architects chose to build a relatively small edifice with three stores that faced the tranquil Boltzmanngasse, thereby avoiding the busy traffic of Währingerstrasse. Concerned with disturbances, they moved the façade two meters further back from the street side to avoid the noise of the already infrequent traffic at Boltzmanngasse.[32]

While they were able to take care of external factors such as noise and mechanical vibrations, the physicists were not yet fully aware of radioactive contamination as a new kind of disturbance. As Meyer admitted, "it was a new concern; we were setting up something untested; the experiences due to the

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[29] Cahan, *An Institute for an Empire*, (1989), pp. 168-175.
[30] Hittner, *Geschichte des Studienfaches Physik*, (1949), p. 73-75.
[31] Golitshek and Eldwart, *Der Neubau des Physikalischen Institutes,* (1915), p. 1.
[32] Protokoll, k.k. Academie der Wissenschaften, Institut für Radiumforschung in Wien, Neubau. 5 June 1909, p. 1, AÖAW.

radioactive 'contamination,' mutual hindrance and so on were absent for the most part."[33] Unfortunately, they located two storerooms for radioactive materials along with the accumulator (a 469 Volt battery) and a transformer in the cellar.[34] Work rooms were grouped on the other side of the cellar, separating the area of research from that of the apparatus and the radioactive sources. Double walls on the external sides additionally limited the amount of radiation exposure. As it turned out, such an arrangement was a mistake, since the radioactive emanations were spread through the whole building and were daily inhaled by the personnel. A better solution was chosen for the stronger radioactive materials. Outside of the building and next to the cellar, they built an underground room covered with thick concrete in order to store the strong preparations and eliminate contamination.[35] It was probably because of radiation precautions that the Institute's design broke with the German architectural stereotype of hosting the director under the roof of the research center. In the Vienna Radium Institute there were no residential apartments either for Exner or Meyer.

While mechanical vibrations and noise had always been familiar disturbances that most could interfere with experiments, the radiation hazards were a vicious, malevolent disturbance that scientists were not ready to face. The first incidents of radiation hazards had just started to appear within the scientific community. In the fall of 1926 Rona spent a few months in the Curies' laboratory in Paris, in order to learn how to prepare polonium sources from Irene Curie.[36] It was there that Rona became aware of the dangers of radioactivity. One of her colleagues and friends, Mme. Cotelle, developed symptoms of overexposure to radiation such as loss of hair and stomach problems. Nonetheless, Rona experienced the possible hazards of radiation herself. One day while she and Marie Curie attempted to open a flask containing a solution of a strong radium salt, a violent explosion scattered glass all over the laboratory.[37] Thus, when, in the beginning of 1927, Rona returned to the Vienna Institute, her experience with radium hazards led her to insist on taking precautions. The whole Institute was highly contaminated. Although hoods were used and the

[33] Meyer, "Das erste Jahrzehnt," (1920), p. 3, (translation mine).
[34] For the description of the interior see Meyer, "Das erste Jahrzehnt," (1920), pp. 4-7; Pawkowicz, *Die Osterraichishe Academie,* (1978), pp. 88-95.
[35] Meyer, "Das erste Jahrzehnt," (1920), p. 4.
[36] Hans Pettersson's report on the investigations regarding artificial disintegration, first half of 1926, GUB.
[37] Rona, *How it Came About*, (1978), pp. 24-5.

rooms were fairly well ventilated, the walls of the chemistry laboratory on the first floor were especially contaminated. Rona recalled that "separated with a narrow corridor was the instrument room, which contained Geiger counters for beta counting and parallel plate condensors for alpha counting."[38] That spatial arrangement resulted in the contamination of instruments which finally had to be carried to the neighboring Physics Institute.

During the Institute's second decade, Rona's own room was one of the most contaminated. As she found out, it was there during the 1910s that Hönigschmidt carried out his atomic weight experiments. Unprotected, in order to homogenize the radium solution, Hönigschmidt often shook the solution by hand.[39] After her accident in Paris, Rona was more cautious. In her effort to open sealed tubes with radium salts with her colleague Gustav Ortner, she insisted on using gas masks, but Meyer even in the late 1920s was unwilling to take her request seriously.

> He laughed and tried to assure me that no danger was involved. However, I was not convinced and bought two gas masks with my own money. When we tried to open the first tube, it exploded, and the same thing happened with the second, scattering radioactive material all around. The gas mask saved us from severe damage. The basement room was closed permanently because it was impossible to get rid of the contamination.[40]

Women's individual bodies occurred as sites of experience, sites where radium and its penetrating radiation literally left their tracks in women's cells. Radiation affected their health and their everyday practices. There are no statistical data for that time concerning the effects of radiation on women's reproductive system or on the health of the Institute's personnel as a whole. Only slowly did scientists become aware of the hazards and the dangers of radium. When Meyer published his book on radioactivity in 1927, he described different types of hazards mentioning also his own accident, with the hope "that this mention will precaution those who work with radioactive matter."[41] When emptying and transferring radioactive liquid from one bottle to another, his fingers were contaminated and, after the first symptoms of radiation burns, the muscles atrophied. Irrespectively of gender, the research

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[38] Rona, "Laboratory Contamination," (1979), p. 724.
[39] Rona, *How it Come About*, (1978), p. 29.
[40] Rona, "Laboratory Contamination," (1979), p. 724.
[41] Rona, "Laboratory Contamination," (1979), p. 724.

personnel of the Radium Institute in Vienna shared the same dangers and hazards, often made worse because they were unaware of the new, life-threatening dangers that radium research reserved for them.

4.3. New Aesthetics: The Architecture of Functioning

While Meyer was mainly concerned with safety issues and the arrangement of the interior, Kupelweiser set an interesting requirement in his donation. The Institute ought to be built in a "pleasant architectural form."[42] At the time the architecture in Vienna was in transition; it was a period of "creative unrest."[43] From the end of the Ringstrasse epoch with its monumental buildings, architecture had shifted through a period of radical change to the *Moderne* movement. The most representative architect of the period was Otto Wagner. The son of a notary, Wagner studied at the Polytechnic Institute in Vienna, the Königliche Bauakademie in Berlin, and the Academy of Fine Arts in Vienna.[44] He paid great attention to the traditional architecture of the city and adopted the Viennese style of weight and monumentality. Yet he certainly broke with his past, establishing his *Nutzstil*, the functional style, arguing for artistic simplicity.[45] His motto "necessity is art's only mistress," was reflected on his buildings and genuinely marked Vienna's architecture during the first decade of the 20th century.[46]

Indeed, "the form of the Institute appeared to meet the artistic demands of the time" as Rainer Pawkowicz notes.[47] Deeply influenced by Wagner's simplicity, the Institute for Radium Research, though it demonstrated nothing of Wagner's authentic architectural skill adopted the principle that "nothing unpractical can be pretty."[48] The form of the building smoothly followed its function. A new science demanded new architectural forms and aesthetics. Ferstel's heavy ornamentation and Renaissance designs did not fit into a modern world. Rather it was efficiency, economy, and the

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[42] Kupelweiser to the Academy of Sciences, August 2, 1908, AÖAW.
[43] Borngässer, "Architecture from the Late Nineteenth Century," (1999), p. 273.
[44] Pintaric, "Vienna 1900," (1989), p. 7.
[45] The *Secession*, a group of radical young painters and architects, was the product of Wagner's former students such as Joseph Maria Olbrich and Josef Hoffman (Borngässer, "Architecture from the Late Nineteenth Century," (1999), p. 276).
[46] Schorske, *Fin-de-siècle Vienna,* (1980), p. 73.
[47] Pawkowicz, *Die Osterreichische Akademie,* (1978), p. 81.
[48] Wagner, *Die baukunst unserer Zeit*, (1979), p. 45.

facilitation of science that Kupelweiser, Exner, and Meyer had in mind when planning the new Institute.

In the original plans, the façade of the Institute combined elements of architectural historicism with an austere structure. The ornamentation was discreet, with simple motifs above the windows, a narrow balcony at the second floor, and external ornamented pilasters. When the Institute was actually built, the façade was simpler with less ornamentation and pure lines, just a simple arch above the entrance and plain motifs above the windows. The new trading zone of radioactivity, the novel identities of the science practitioners, and the boundary character of the object of their research were all materialized in the unadorned façade of the new building. The connecting bridge to the Physics Institute was hanging discreetly at its right side. A few architectural elements such as the balcony and the akrotiria on the four upper corners of the roof signified the transition from *Historismus* to *Moderne* (see figures 4.2 and 4.3).

Figure 4.2 The façade of the Institute for Radium Research (Courtesy Austrian Academy of Sciences)

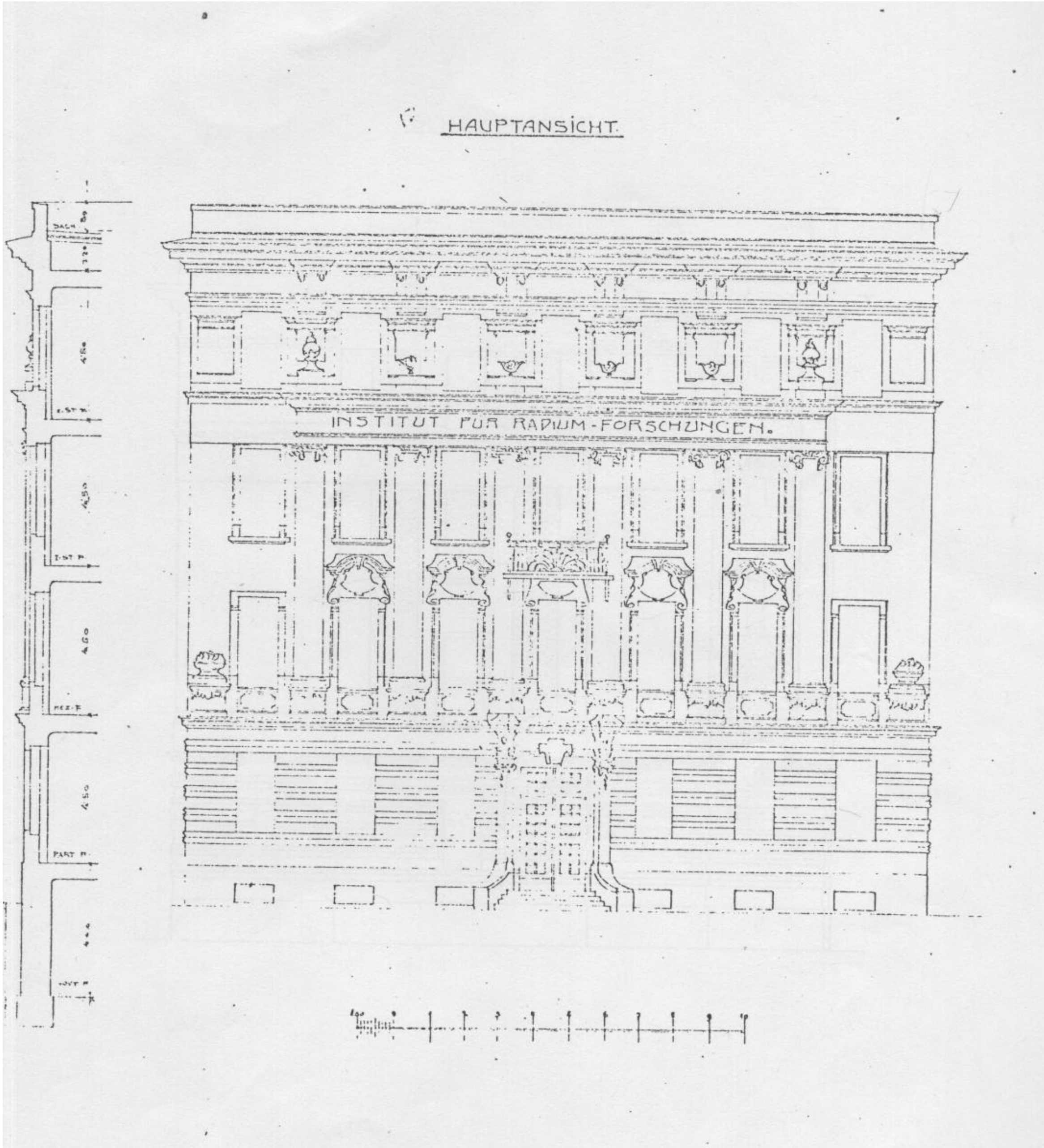


Figure 4.3 The Institute for Radium Research circa 1950 (Courtesy Austrian Academy of Sciences)

Radiuminstitut

There is more architectural evidence for shifts in the culture of physicists continued inside the building. The interior was equipped with modern facilities that the physicists at Türkenstrasse would probably have difficulties imagining. All work rooms and offices had access to natural light and were equipped with thick roller blinds to protect experiments and experimenters from the unpleasantly hot summer sun. During the cold Viennese winters the central gas heating created a pleasant working atmosphere, relegating the chilly winters at Türkenstrasse to the status of a nightmare. Each floor was equipped with gas and with two chemical stoves, a new technological development. The electrical company *Stögermayr* designed the electrical system, providing each floor with direct, alternating and accumulator current, currents of different strength and voltage for different types of research. Delicate, simply ornamented lamps were installed in the Institute, illustrating the value of functionalism combined with artistic pleasure. Meyer's office was expensively furnished from the noted *American Trade Company.* There were telephones in each working space, making the Institute one of the most prestigious and technologically advanced of its time.[49] The construction of the specialized Institute for Radium Research provided not only unique opportunities for research but also new cultural and institutional identities to the scientists that it housed.

4.4. Fashioning a New Identity

I argue that different internal arrangements of space, diverse inclusions and exclusions of particular facilities for socializing, and external architectural styles and surroundings "build" different scientific identities. The architecture of the laboratory, the daily working place of scientists, imposes, defines, and maintains who the practitioners are, how they fashion themselves and their work. Transformations in scientific identities are inscribed in the transformed architecture of laboratories. At the same time changes in architectural design construct and reflect scientific identities in transition.[50] It was probably this that Exner had in mind when, embarrassed as he was by the provisional laboratory at Türkenstrasse, he left Vienna before his international colleagues arrived for the meeting of German scientists and physicians in 1894. Only

[49] American Trading Company to Meyer, May 20, 1910, AÖAW.
[50] For support of this argument see Gieryn, "Two Faces on Science," (1999), pp. 423-455.

when the new physics laboratory opened its doors in 1913, did Exner feel comfortable as a host of Einstein and a number of other prominent scientists of his time, during the eighty-sixth meeting of the German scientists and physicians. The attendance exceeded the 7,000 participants, and, in the words of Walter Moore, "The imperial city had never looked more splendid than in these last autumn days of its glory."[51] Viennese physicists, overwhelmed by their new quarters, considered themselves prestigious as never before. As part of the conference, the Viennese physics community organized a reception at the imperial court, a banquet at the *Rathaus,* and a music event in the halls of the physics institute, where physicists and their wives danced to the rhythms of the Viennese waltz. Acquainted with the artistic circles of the city, the physicists were deeply involved both in academic politics and in the high culture of Vienna.

Exner celebrated the construction of the new natural science quarter as a symbol of scientific authority, as having the potential to bring Vienna to the forefront of physics research, and as a personal victory after twenty years of frustrations and difficulties in the institute at Türkenstrasse. Exner was already sixty-four years old when his institute, the *II Physikalisches Institut*, moved to the new complex of buildings at Währingerstrasse 42. From a few ramshackle rooms in the *Zinshaus* at Türkenstrasse, Exner finally obtained a spacious new institute with lecture halls for more than 200 students and equipped with a pendulum tower.[52] Although he was no longer at the peak of his scientific career, he certainly enjoyed the heydays of his administrative role in both the Radium and Physics Institutes. For the young physicists, such as Meyer and Schweidler, the Radium Institute meant much more. The more prestigious it was, the more esteemed Meyer and his colleagues became in the international scientific community and the more possibilities they foresaw in working in an exiting new field.

As early as 1904, Rutherford congratulated Meyer and Schweidler for their work on classifying new radioactive elements.

> I have read with the greatest interest the reprints of your valuable papers which you have kindly forwarded to me. The results in your last paper on radiolead have been of special interest to me and I congratulate you at your proofs of the identity of the

[51] Moore, *A Life of Erwin Schrödinger,* (1994), p. 57.
[52] Golitschek and Eldwart, *Der Neubau des Physikalischen Instituten,* (1915), p. 2.

products of radiolead with those of active deposit of radium. There can now be no doubt of their connection. [53]

In 1908, deeply involved in radioactivity research, Meyer was already known to the international scientific community for his work on magnetic-deflection experiments. The next year he was appointed to Exner's assistant and in 1910 he became an *ausserordentliche Professor* at the University of Vienna. Not surprisingly, when that year the International Standard Committee was founded with Rutherford as its president, Meyer was appointed its secretary. Given his internationally distinguished career, the recognition by his Austrian colleagues was absolutely expected. When the Institute opened in 1910, Meyer was just thirty-eight years old and its undisputed director. At the culmination of his career he projected onto the Institute his concern for fascinating research and pioneering work in a promising field. Instead of shabby physics lecture halls and physics lecturers hosted in medical institutes, the Viennese physics community acquired its own quarter. The buildings finally gave tangibility to what Exner was struggling to accomplish for years: the physicists, and, more specifically, those working on radioactivity became visible.

4.5. Reinforcing Collaborations

Besides fashioning a new identity for the physicists at Boltzmanngasse, the Institute's building did something more. It enforced collaboration within its walls, preserving the ethos of collegiality from the days when Exner's circle met in the coffeehouse at the corner of the old institute or at his house on Währingerstrasse. Open to women, the Institute preserved the same working conditions for both men and women. Meyer played an important role in securing laboratory space for those who needed it, irrespective of their gender. For example, in the early 1920s it was Meyer who asked Rona to join the Institute. "What a windfall for me," Rona mentioned, surprised "to be able to work full time in my chosen field in well-equipped laboratories, with scientists expert in the field of radioactivity!"[54] She recalled the pleasant atmosphere, the collaborative research, and her feeling of belonging to the "family" of the Institute, all deriving mainly from Meyer's

[53] Meyer, "Die Vorgeschichte," (1950), p. 2.
[54] Rona, *How it Came About,* (1978), p. 15.

personality and his personal interest in the work of each one of his students and staff. Although, as the director of the new Institute, Meyer acquired the power to choose among different research programs and to invite the scientists of whom he approved, hiring and firing *Assistenten* and personnel as he chose, he remained a paternal figure for his young colleagues, as Exner had previously been before him.

Meyer's impact on the work of his employees and colleagues becomes evident in the words of Blau who worked at the Institute for more than sixteen years. In 1932 with a grant from the Federation of Women Academics of Austria, Blau visited the Physics Institute in Göttingen. As she reported to Berta Karlik, her friend and colleague in Vienna "Tomorrow, with my heart trembling, I will visit Pohl for the first time. When one is used to Professor Meyer's friendly, morning greetings, Pohl's monarchical nods seem odd to one."[55] Robert Pohl, professor of experimental physics and director of the Institute in Göttingen, obviously had a different administrative style than Meyer. Authoritative and inaccessible, Pohl created an unpleasant atmosphere in his institute. It is not surprising that when Marie Curie offered Blau a research position in her laboratory in April 1933, she was more than happy to accept it.[56] "I have been very nicely taken up by Madame Curie," Blau reported to Meyer. "She told me that I can choose my own topic."[57] Nonetheless, she insinuated that even in Curie's laboratory things were far different from Vienna. "Irene Curie is very nice but not so nice as Madame Curie or Mouseur Jolliot."[58] The collegial atmosphere and the ethos of working at the Institute in Vienna were certainly unique. It is this atmosphere that is strongly reflected in the plans of the new Institute drawn up collaboratively by Meyer and Exner. At the same time I argue that the architectural design of the Institute reinforced a collegial environment for scientific research.

4.6. Gendering the Interior: Laboratory Spaces in the Institute for Radium Research

Using architecture as a way to explore the space where women and men involved in radioactivity research, I move the focus on to the interior. I look for

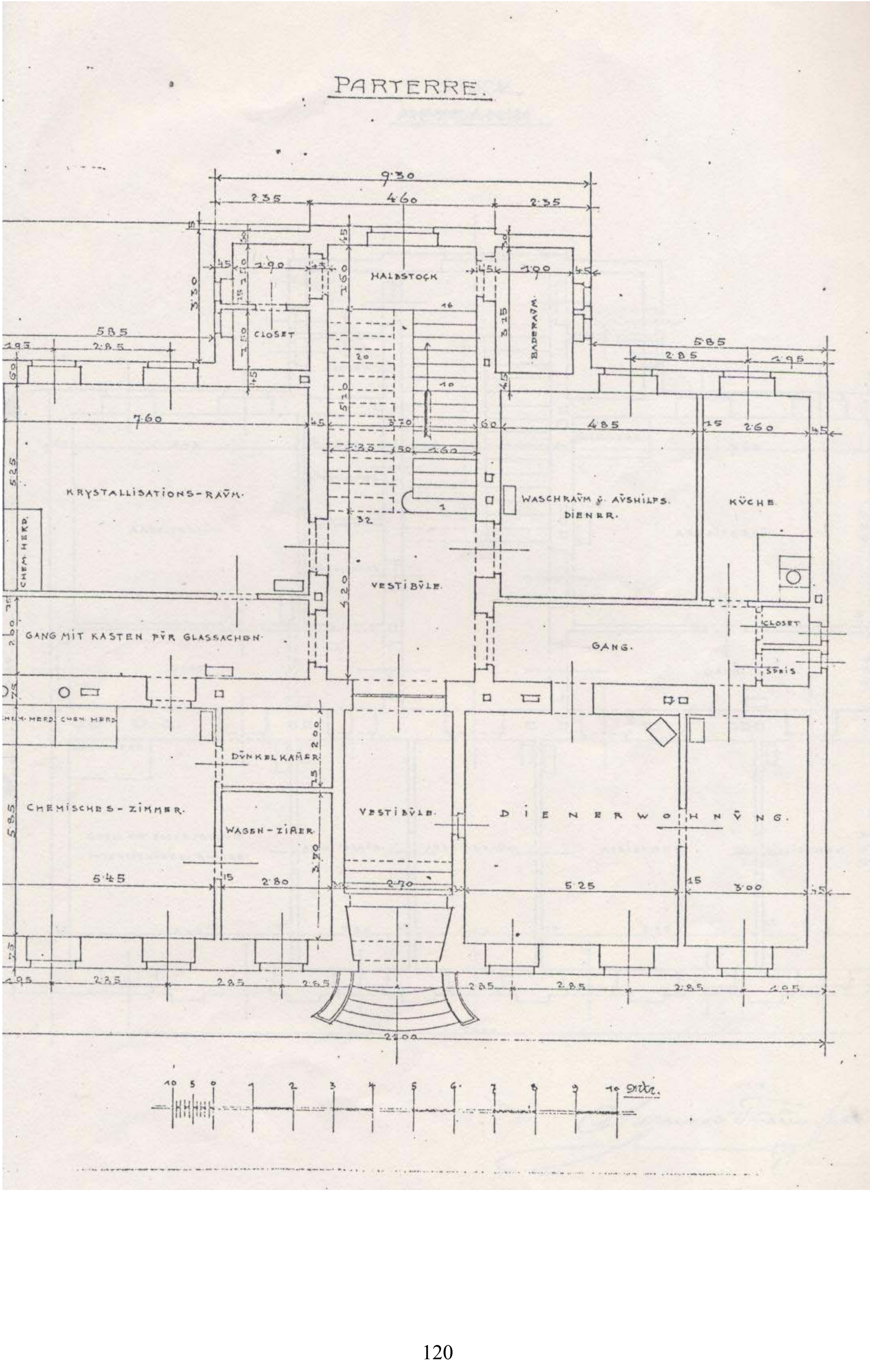
[55] Blau to Karlik, October 22, 1932, AÖAW.
[56] Galison, *Image and Logic*, (1997), p. 151.
[57] Blau to Meyer, April 29, 1933, AÖAW.
[58] Blau to Meyer, April 29, 1933, AÖAW.

exclusions and inclusions based on gender, for ownership of space, and for gender assumptions in architectural design. Before the architects began to draw the detailed design of the Institute, Meyer and Exner had already defined for them the exact space requirements for laboratories, offices, and support rooms.[59] As physicists who shared a strong collegial ethos, they placed a high value on a welcoming and warm environment for their research personnel, combining spaces for socializing with spacious research laboratories.

The interior was characterized by a central symmetry around the axis of the staircase. In a lean form, the staircase suggested its function as a means for vertical traffic. In each mid-floor the staircase had large open landings that facilitated communication and gave space for people to stop and talk. Furthermore those landings had enough room to accommodate a bathroom and the toilets on the sides. The bathroom was designed for the needs of those who worked with radium preparations or polonium sources and often contaminated with radioactive powder. It was not at all unusual for the researchers to take a shower or wash the dirty laboratory uniforms. Separate toilets designated for men and women pointed to the gendering of scientists in the architect's mind.[60]

[59] Meyer, "Das erste Jahrzehnt," (1920), p. 3.
[60] Although from the architectural plans of the Institute it is not obvious that there were more than one toilets in each floor, Meyer refers to them in plural (Meyer, "Das erste Jahrzehnt," (1920), p. 6).

Figure 4. 4 The architectural plan of the ground floor of the Institute for Radium Research (Courtesy Austrian Academy of Sciences)



As Cooper et al. have argued, in Dunedin, New Zealand, between 1860 and 1940, differences in the provision of public toilets for men and women point to the gendering of citizens.[61] As women became more public, the need for privacy and public sanitary installations became more apparent. Apparently, as the early twentieth century saw an increase in women's participation in science, architecture slowly accommodated the new body politics that came along. Similar body politics characterized the case of the Physics Institute in Heidelberg built between 1909 and 1913. [62] Although the original plans did not include toilets for women, they had to be modified to include separate sanitary installations in order to meet the approval of the State. [63] The architecture of the Vienna Institute and the separate sanitary installations that it included from its very first design, reflect the unique gender politics in the Institute. The existence of separate spaces of 'public privacy' within the Institute underlined, implicitly, the existence of both men and women in research laboratories. Women's bodily practices and needs obtained physical reality within the Institute's walls. Meyer and Exner were not only familiar with the fact that there were women working in physics. They further promoted it by acknowledging their potential existence and needs in the Institute.

A second remarkable and unique architectural element enforced the particular politics of institute and laboratory keeping. The ground floor housed the Institute's mechanic and maid.[64] The mechanic's apartment was located right next to the entrance and directly linked to a room designated for cleaning and washing the devices used in chemical procedures, which was operated by the cleaning personnel.[65] Such an arrangement freed the time of the researchers who were mainly concerned with their own scientific projects. Women, who stereotypically are those who are expected to act as assistants and housekeepers, were free to do their scientific work in the same manner as their male colleagues did. A similar situation occurred in the Kaiser Wilhelm Institute for Brain Research in Berlin around the same period. As

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[61] Cooper, "Rooms of Their Own," (2000), pp. 417-433.
[62] Auer, *Das Physikalische Institut in Heidelberg*, (1983), pp. 9, 31.
[63] Auer, *Das Physikalische Institut in Heidelberg*, (1984), p. 10. I thank Christoph Hoffmann for pointing out this article to me.
[64] Meyer, "Das erste Jahrzehnt," (1920), p. 4.
[65] From the early days of the Institute to 1938, Karl Kornher was the mechanic and until 1922 Stanislaus Kijowski was responsible for cleaning the Institute. In 1924, Kijowski was promoted to laboratory assistant (*Laborant*) until his retirement in 1936, when his son Julian Kijowski took over the

Annette Vogt describes, the personnel responsible for the housekeeping of the Institute were also responsible for cleaning the apartments of all scientists and technical assistants whose residence was near the Institute. Such an arrangement, Vogt argues, created unique conditions for the women working at the Institute, freeing their time from everyday home tasks and enabling them to play an exceptional role in scientific research.[66]

Also on the ground floor but on its left side, were two rooms for chemical work, a dark room, and a space for precise measurements of radioactive materials, forming the main radiochemical laboratory of the Institute. In the hallway, showcases hosted glasses for chemical analysis and other devices. During the 1910s, Victor Hess, who worked as the first *Assistent* at the Institute, was responsible for radiochemical tasks. As he later recalled,

> the housing of the chemistry laboratory at the ground floor was unfortunately a wrong choice: the highest story or a particular building for radiochemistry would have been a better solution, but that was unavoidable, because there we often worked with big amounts of preparations.[67]

Safety issues came up again and again during the following years. The physicists, unaware of the dynamics of their new field and the danger of radium, chose inflexible structures. “Indeed, in any laboratory design, planning for the future is nearly as important as is planning for the present,” as James Collins argues, describing the designing of the Lewis Thomas Laboratory of molecular biology at Princeton in the 1980s.[68] Although Meyer and Exner tried to plan for their future research in radioactivity, the changes were unpredictable. It was only in 1966 that Berta Karlik, director of the Institute after the World War II, finally managed to restructure the building “with the help of a young, very competent architect.”[69] Bringing down a few walls, Karlik arranged to fit in a Cockroft-Walton accelerator and added one more floor on the top. From the electromagnets and the accumulators of the 1910s to the big accelerators of the 1950s the shift was indeed inconceivable.

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position. In 1930, Josefine Schörg was hired as cleaning lady (Akademie der Wissenschaften in Wien, Almanach für die Jahren 1920-1938, Wien, AÖAW).

66 Vogt, “The Timofeeff-Ressovsky’s,” (2000), p. 4.

67 Hess, “Persönliche Erinnerungen,” (1950), p. 44, (translation mine).

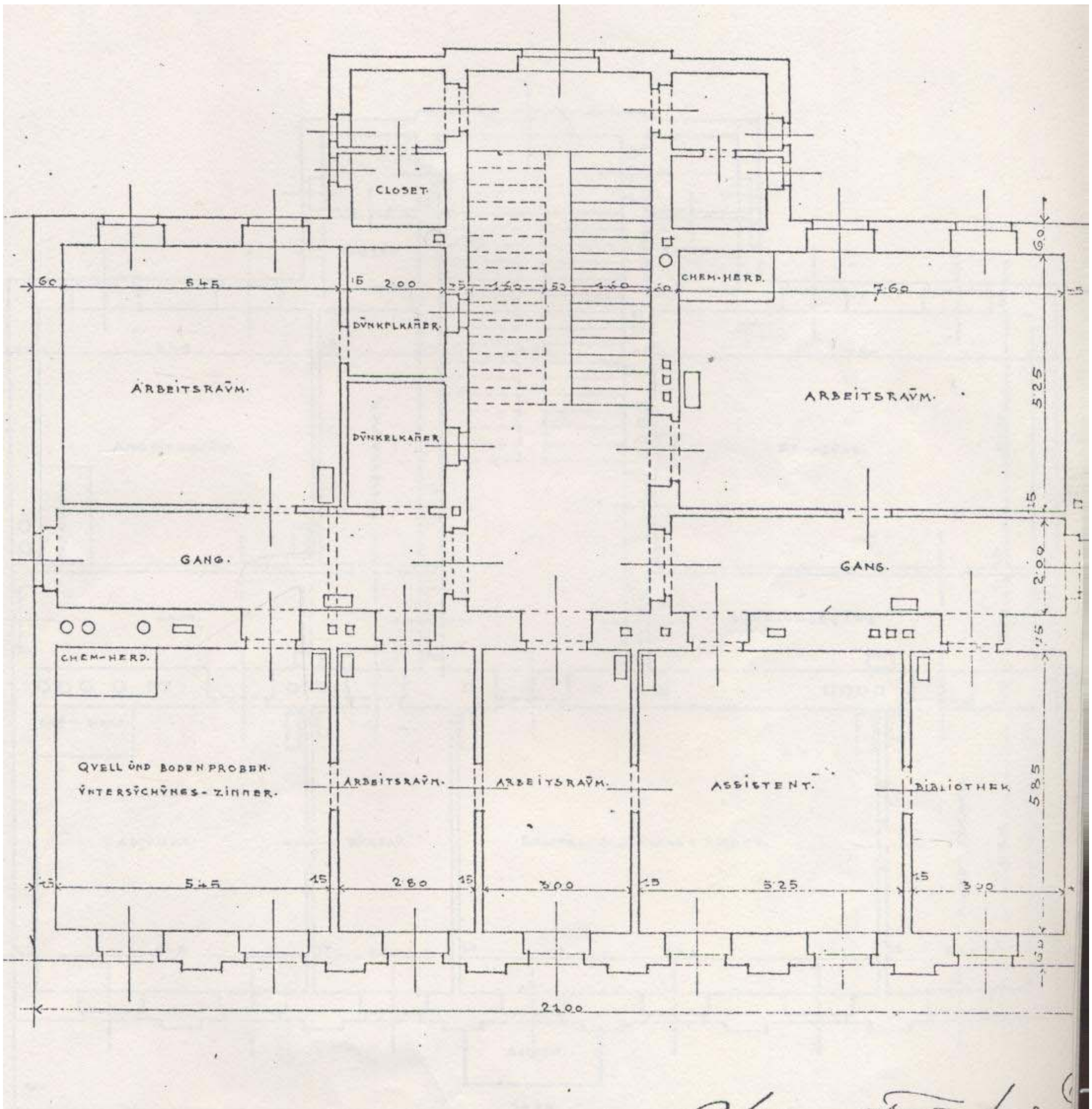
68 Collins, “The Design Process,” (1999), p. 404. See also Pratt, “Design of a Biomedical Laboratory, Part I and II” (1985), pp. 141-143 and pp. 179-181.

69 Karlik to Pettersson, January 16, 1966, GUB.

One of the most important features of the Institute's architecture was located on the first floor. A small library serving the purpose of promoting communication among the researchers and providing a space for social activities transformed the first floor into the heart of the Institute. Facing Boltzmanngasse at the right corner of the building, the library hosted only specialist literature on radioactivity. "For the remaining literature, one had to depend on the big neighboring library of the Physics Institute (as well as the institutes of mathematics and chemistry)," as Meyer explained, indicating the close collaboration of the neighboring institutes.[70] Besides functioning as a literature source, the library was also destined to house the most exciting discussions on ongoing experiments, scientific developments, political upheavals, and the cultural life of Vienna. Every evening for the next twenty-eight years the researchers met informally at the library to drink their coffee and engage in conversations with their colleagues. "As I remember," Agnes Rodhe, the daughter of Hans Pettersson, one of the researchers at the Institute recalled, "every day at four o'clock they had the so called "jause," afternoon tea, and all the institute met, at least the ones who were free to drink coffee, chocolate, or tea and have deserts."[71] Strong friendships among the researchers originated from that period and were developed through the collegiality of those coffee hours. "We all ended up close together," Hess later remembered, "and the collegial relations were extremely cordial. I thank here my friends Kohlrausch, Schrödinger, Przibram, Paneth, Hevesy, and Thirring, all in the old Exner-circle. Joined together, so to speak, we built a family."[72] Hess's office was actually next to the library with direct access to it (see figure 4.5).

[70] Meyer, "Das erste Jahrzehnt," (1920), p. 4, (translation mine).
[71] Rodhe, interview by the author, September 22, 2001, Göteborg, Sweden.
[72] Hess, "Persönliche Erinnerungen," (1950), p. 45, (translation mine).

Figure 4.5 The architectural plan of the first floor of the Institute for Radium Research (Courtesy Austrian Academy of Sciences)



The above described setting reinforced the role of the library as a place where people could meet colleagues and friends, discuss the latest scientific issues, and socialize. The move from the neighboring coffeehouses to the more secluded Institute's library for the social meetings was also a move from the public, *in vivo* laboratory of the *Mediziner-Viertel* to the semi-private domain of the Radium Institute. Scientific discourse was moved out of coffeehouses and Exner's residence to a new institution that legitimated the Viennese researchers on radioactivity and assigned them a unique institutional persona. From the coffeehouse to the Institute's library, the physicists carried over the Viennese cultural identity that characterized their scientific ethos. After all, the library served as a way to convey a meaning: researchers working on radioactivity and standing on the border zone between physics and chemistry claimed their own, distinct community at the intersection of the Physics and Chemistry Institutes.

Obviously women had social as well as professional access to the library. As Karlik reported in a letter to Pettersson, "the tea-standard has been very high lately; no political remarks. Ortner getting more and more interested in theory and taking part regularly; a theoretician called Ludloff who has now got his *Dozentur* here (he comes from Breslau), Frau Dr. Seidl occasionally even Sexl coming. Mattauch belongs already quite to the family."[73] Franziska Seidl became a *wissenschaftliche Hilfscraft* at the first Physics Institute and in 1924 she was promoted to *Assistentin*.[74] She habilitated in experimental physics in 1932 and in 1933 received her *Venia Legendi,* becoming a *Privatdozentin* at the University of Vienna. Seidl taught a course every semester from 1933 and on and focused on several topics in experimental physics, including x-rays and their use.[75] By the end of 1938 Josef Mattauch, who held the position of *Assistent* at the first and third Physics Institutes, moved to Berlin as director of the Kaiser Wilhelm Chemistry Institute.[76] Theodor Sexl was *Assistent* in Vienna's *Technische Hohschule* in 1926 and 1927. In 1928 he moved to the Physics Institute.[77] Hans Ludloff came to Vienna in 1938 from Breslau to offer a class on

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[73] Karlik to Pettersson, February 3, 1938, GUB.
[74] Hittner, *Geschichte des Studienfaches Physik*, (1949), p. 243. See also Bischof, *Physikerinnen*, (1998), p. 13.
[75] Vorlesungen an der k. k. Universität zu Wien, especially for summer semester 1935, AÖAW.
[76] Hittner, *Geschichte des Studienfaches Physik*, (1949), p. 241.
[77] Hittner, *Geschichte des Studienfaches Physik*, (1949), p. 242.

quantum theory.[78] Apparently, the library functioned as the meeting point not only for the research personnel, men and women, of the small Radium Institute, but for the whole physics community. The afternoon "jause" was more than a coffee break and the Institute's library more than the mid-point between the researchers on radioactivity and the physicists from the neighboring Institute. The conjoint gender issues of architectural, epistemic, and social access were all reflected in this small room that hosted passionate discussions for almost three decades.

Besides the regular "jause," the women of the Institute were also visible during the formal visits of internationally known physicists. When, for example, in 1933 Thomson and his wife paid a formal visit to the Vienna Institute, Karlik had to entertain them socially with the rest of her colleagues. "At the Przibrams, we had the most delightful afternoon," as she reported to Pettersson on 26 July 1933.[79] Researchers spent so much time in the Institute that even their social lives were closely connected to the life of their experiments.[80] Thus every effort was made to make the environment as habitable as possible and the research facilities as spacious as the size of the Institute permitted.

At the back side of the first floor facing the inner courtyard, there were two spacious work rooms, while at the front side there were two smaller ones, and a research room for sources and samples from the mines. In the second floor there were two offices, a room for the electromagnet,[81] one with a collection of apparatus mainly for measurements, and a big room for spectroscopic analysis with a balcony facing Boltzmanngasse. As Meyer pointed out, there were no instruments for educational demonstrations since the Institute, breaking with the stereotypical German model for science institutes, was designed only for research and not for teaching.[82] In addition to a small room for drying the radioactive residues and a workshop, the third and last floor consisted mainly of work rooms and two dark rooms for photographic tasks.

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[78] Hittner, *Geschichte des Studienfaches Physik*, (1949), p. 244; Vorlesungen an der k. k. Universität zu Wien, winter semester 1937/38. AÖAW.

[79] Karlik to Pettersson, July 26, 1933, GUB.

[80] For example, in the same letter to Pettersson where Karlik reported the Thomsons' visit, she also explained how she shifted her experimental project on radon emanations around their visit (Berta to Pettersson, July 26, 1933, GUB).

[81] The company *Siemens and Halske* provided the magnet which worked with direct current of 440Volt, 122,000Amper and 15KW (*Siemens and Halske* to Meyer, July 15, 1910, AÖAW). A long list of the most advanced instruments and apparatus was finally purchased from *Siemens and Halske* for the new Institute (*Siemens and Halske* to Meyer, February 25, 1910, AÖAW).

[82] Meyer, "Das erste Jahrzehnt," (1920), p. 6.

Peculiar to the Institute's design was that the work rooms in each floor were all interconnected providing access to all practitioners. One was able to access each room from at least two different doors and interconnectedness was the inevitable result. Doors served to articulate the flow of scientists. Men and women had access to all of these rooms irrespectively of their gender. As the pictures of Rona and Georg Stetter illustrate, what mattered was their scientific expertise, their knowledge of operating a specific apparatus, and their need to perform an experiment (see figures 4.6 and 4.7).

Figure 4.6 Elisabeth Rona in the Institute for Radium Research, circa 1925 (Courtesy Agnes Rodhe)

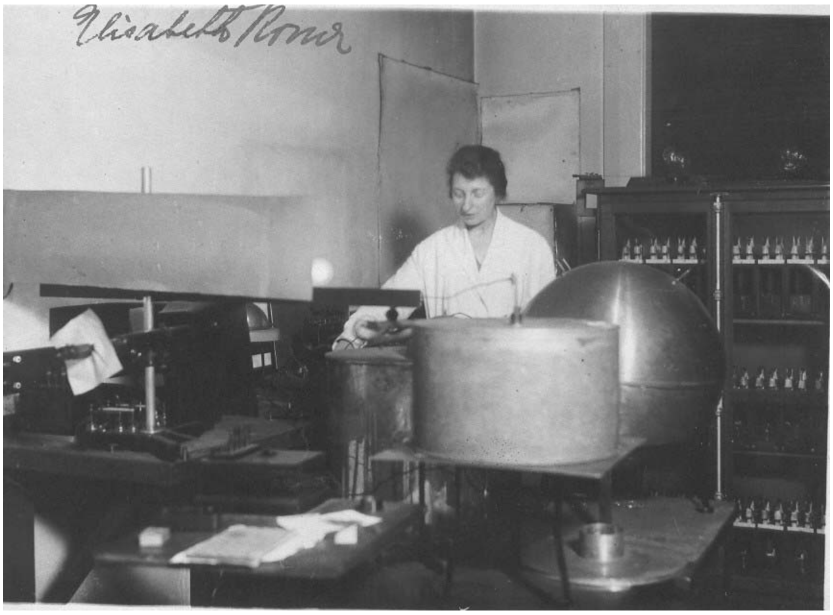
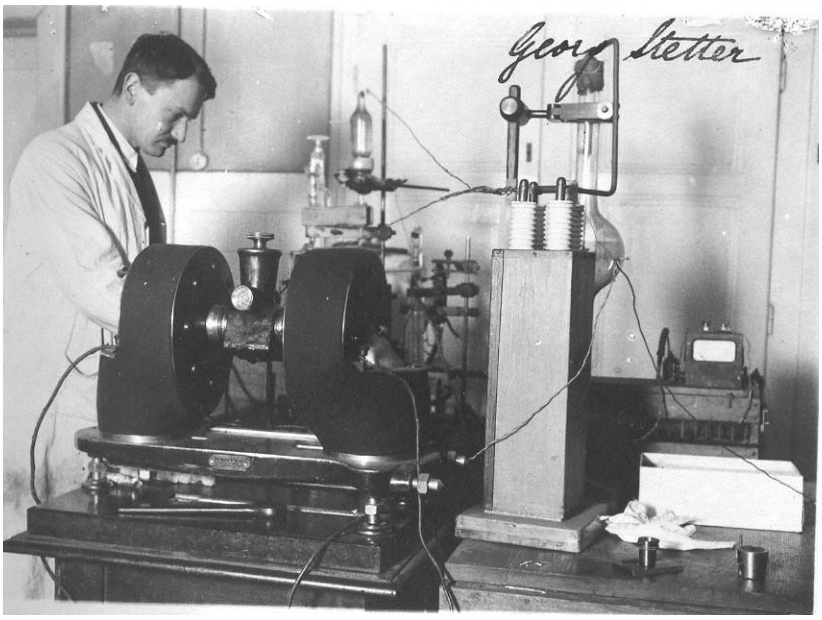


Figure 4.7 Georg Stetter in the Institute for Radium Research, circa 1925 (Courtesy Agnes Rodhe)



As Forgan mentions for the case of the early 19th century England, "Laboratories were not public spaces, but regarded with intense personal possessiveness."[83] Control over space was clear for the case of the Vienna Institute as well. There was little confusion over who was responsible for keeping space and equipment neat for the next user or to whom instruments and laboratory benches belonged. Interestingly enough women controlled their own space within the Institute. Reporting on the events and experiments run at the Institute in her regular correspondence with Pettersson, Karlik several times conveyed information on laboratory space. While she was explaining one of her experiments, Karlik noted, "I had locked the room so that only a 'Funkionär' could have entered,"[84] and later on, that Przibram "could hear the pump running in my room all the time."[85] In early 1920s, when Rona entered the Institute, due to the shortage of office space she was assigned Exner's ex-office.[86] Moreover, from several of the Institute's publications it becomes obvious that personal possessiveness concerning instruments was also acknowledged and respected from the personnel. For example, in 1927 Kara-Michailova thanked Stetter for his generosity in lending her his apparatus for her experiments on the brightness of scintillations.[87] In a letter to Pettersson in 1933, Karlik mentioned that "Ortner had actually borrowed the Cenco-Hyrac-pump (we had agreed on that) and that he and Frau Sehork had just replaced it."[88]

Changes in the ways experiments were conducted and research was performed often required a collaboration of two or more scientists. New scientific demands shaped and transformed spatial arrangements. At the same time, specific transformations in laboratory design ensured personal space allotted to each practitioner and a mingling of men and women in the work place. The following pictures indicate an interesting symmetry in gender arrangements of space at the Institute.

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[83] Forgan, "Context, Image, and Function," (1986), p. 110.
[84] Karlik to Pettersson, August 1, 1933, GUB.
[85] Karlik to Pettersson, 9 March 1934, GUB.
[86] Rona, *How it Came About*, (1978), p. 15.
[87] Kara-Michailova, "Helligkeit und Zällbarkeit der Scintillationen," (1927), pp. 357-368.
[88] Karlik to Pettersson, August 1, 1933. GUB.

Figure 4.8 With the focus on Kara-Michailova and her desk the picture is fuzzy on one of her male colleagues in the back (Courtesy Artur Svansson)

Figure 4.9 While the picture is centered on Friedrich Hecht, this makes imperceptible one of his female colleagues at the back of the laboratory (Courtesy Agnes Rodhe)

Spatial arrangements, nonetheless, reflected not only the architects' and the directors' gender assumptions but they further encouraged specific gender relations in the Institute. This is evident in the laboratory layout and in the collaborations that occurred within the core group of most productive researchers in the Institute. Although the early laboratory layout had a bench against the wall, in the Institute there were instead free-standing tables placed around the room. While such an arrangement could accommodate more co-workers, it gave space for informal gatherings like the one in the following picture.

Figure 4.10 Elisabeth Rona, Elisabeth Kara-Michailova, Berta Kalrik, and Hertha Wambacher are gathered around the same desk at the Institute for Radium Research , circa 1925 (Courtesy Artur Svansson)

At the same time the architecture of the Institute, by facilitating informal gatherings and the mingling of men and women in the laboratory encouraged certain politics of collaboration. It was not by chance that from 1920 to 1938 thirty percent of the total collaborations were between men and women while thirteen percent were among women. More interesting is the fact that women who worked with men were as prestigious and well-published as their male colleagues. For example, both Kara-Michailova and Karlik collaborated extensively with Przibram, the first *Assistent* of the Institute and most well published of the physicists in the *Mitteilungen* and Pettersson, who was second in the number of publications. It is here that architecture serves as evidence of the changes in the gender assumptions among the physics community in Vienna, and it is also here where it becomes obvious how the design of the laboratories encouraged the interaction of men and women under the roof of the Radium Institute.

4.7. Fashioning New Gender Identities

The women and men who inhabited the new Institute constructed and shaped new identities. The architectural style and the spatial location of the Institute reveal the intentions of its designers, their assumptions, and the image they wished to convey. Yet architecture not only reflects but, as in the case of the Vienna Institute, further emphasizes the scientific culture adopted in an institution, fosters collegial relations among the personnel, and constructs gender identities performed by the researchers. Since the Institute was devoted exclusively to research scientists saw themselves less as physics teachers and more as experimenters. Some of them collaborated closely, shifting their identities from single researchers to collegial partners within small groups. Working under the welcoming and supportive guidance of director Meyer, physicists experienced a stable, locally centered point of reference through their work in the Institute. Their daily meetings in the Institute's library for afternoon coffee and discussions of internal scientific issues, as well as political or cultural matters, provided them with a collective identity. At the same time by working in a laboratory that its architecture reminded daily the researchers that women were active members of the scientific community, the social process of shaping disciplinary identities was clearly a gendered one. Internal spatial arrangements reflected the structure of certain gender assumptions of who could be an experimenter and for whom the doors of the Institute should open. Instead of inhibiting women's work in radioactivity research, the interior architectural design and the gender background assumptions that made it possible, facilitated women's attempts to forge careers for themselves. Reserving their own space, women were able to perform their own work as creative researchers and not as mere assistants of their male colleagues.

There is, however, a further historiographical consequence of taking the relation between science and its architecture seriously. Besides something malleable that different architectures assign to the identities of the scientists, they also reflect different kinds of scientific collaborations, the formation of new disciplines, and the dynamics of interdisciplinary research. Historically, the significance of the relation between architecture and the laboratory is to demonstrate that disciplinary boundaries are in flux. In the case of the Radium Institute, men and women brought inside their laboratories their interdisciplinary interests formed in the *Mediziner-Viertel* outside. Eventually, what the Institute demonstrated through its architecture was the dynamic of hosting a boundary object. Located between the Physics and the Chemistry Institutes, the building actually made a statement: radioactivity was clearly in the border zone of physics, chemistry, and medicine. As time passed, this statement was modified and adapted by utilizing the Institute's library, for example, or the bridge that connected the physics to the Radium Institute. Taking advantage of their unique positioning in the *Mediziner-Viertel*, women physicists entered and maintained positions in the field of radioactivity.

The First World War forced radioactivity researchers to rearrange their priorities and slow down their research. Yet, after the end of the war there was a renaissance in the field, especially in the Vienna Institute. Research experience and collaborations acquired in the earlier years proved to be valuable in the interwar period. Unique political circumstances at the academic and state level fostered equally unique gender roles in the Viennese political scene and, by extension, at the Institute. Red Vienna, the Viennese socialist experiment from 1919 to 1934 was not only reflected, but was to a great extend constructed within the *Mediziner-Viertel*.

CHAPTER 5
THE INSTITUTE FOR RADIUM RESEARCH IN RED VIENNA, 1919-1934.

Concerning the status of women scientists in the United States, Margaret Rossiter argues that "although many persons felt around 1920 that the full acceptance of scientific careers for women was now to be a reality, they were to be sadly disappointed, for women scientists made little progress in the next two decades."[1] Employment policies along with social and economic patterns established earlier in the 20th century "systematically channeled women into secondary roles."[2] During the 1920s, nonetheless, social patterns, economic policies, and government politics were not global. In the city of Vienna universal suffrage in 1919 brought the Social Democratic Party (SDAP) to power and gave them absolute control of the municipal government. In what has come to be called 'Red Vienna' Social Democrats retained their power from 1919 to 1934 and carried out extensive social reforms. During this period, as the historian Anson Rabinbach argues in his study of Austrian Socialism, "The only Socialist party to hold absolute power in a major European capital, Austrian Social Democracy combined its traditional orientation towards *Bildung* with the project of municipal socialism by turning Vienna into showplace of Social Democratic institutions designed to transform working class citizens into a 'socialized humanity' by a politics of pedagogy."[3]

From the housing projects and educational reforms to the admission of women to those academic institutions that tenaciously kept their doors closed to them even after the end of the First World War, the basic motive of the Social Democrats was to reconstruct the working and middle class according to socialist standards. Among the ongoing reconstructions was that of the meaning of sexual difference in the Viennese society. The construction of gender was put forward through the party's discourse and its reformative social projects. Having established their intellectual and political power through the control of the municipal government and some of the academic institutes, Social Democrats were able to provide a new conceptual framework for

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[1] Rossiter, *Women Scientists in America,* (1984), p. 129.
[2] Rossiter, *Women Scientists in America,* (1984), p. 129.
[3] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 7.

understanding the relationship between men and women. It was within this framework that women conceived themselves and were able to become active participants in the new social and political status. The impact of the First World War on the gendering of occupational positions played also an additional role. As the Viennese mathematician Olga Tausky-Todd recalls

> Careers for women before World War I were, as far as I remember, primarily as teachers in girl's schools, secretaries, shop assistants, domestic service, nurses, dressmakers, and things of that sort. All this was changed greatly during the war and it never went back the way it had been, though some of the positions acquired during the war years went back to men afterwards. I remember very well in the buses and trams the fares were collected by women and even the drivers were occasionally women. All secretaries were now women. Nurses had been given very intense training, including university courses, and their profession became highly respected. Women teachers had to have far greater training than was required before—even Ph.D in the better high schools. [4]

In that ongoing and busy construction of gender the academic community occupied a central role. Although the socialist reforms were aimed mainly at the proletariat, the reformists were nurtured in the *Mediziner-Viertel* and the left academic community. From the party leader Otto Bauer to the councilor for health and social welfare Julius Tandler, to the key figure in the *Vienna Circle,* Otto Neurath, the socialists gathered in the *Viertel,* making politics on an intellectual level. The *Mediziner-Viertel* was transformed into one of the main experimental laboratories where the Social Democrats instigated and tried out their social reforms. Benefited by this ongoing political process, women entered several academic institutions. It is indicative that while just before the war only one woman entered the university for every 12 men, at the end of the Red Vienna era the ratio had increased to 1:2.8.[5]

The Institute for Radium Research and the field of radioactivity was one among other scientific areas that women gained entrance and succeeded in notable achievements. A closer look at the gender profile of the Institute from 1920 to 1934 reveals those procedures that transformed the gender assumptions about working in science. It also emphasizes the fact that only the city of Vienna and a few of its Institutes were "Red." In general, well-established institutions such as the University

[4] Tausky-Todd, "Olga Tausky-Todd: An Autobiography," (1985), p. 314.
[5] Tuma, "Die österreichischen Studentinnen," (1993), p. 81-82.

of Vienna and its politics of employment as well as the Austrian Academy of Sciences remained almost intact, proving the limitations of the socialist power.

5.1. Gender and Politics in Red Vienna

At the end of the First World War peace treaties led to the construction of the First Austrian Republic on November 1918 and Vienna was proclaimed its capital. "Austria is what is left," as the French Premier Georges Clemenceau is quoted to have said.[6] After the Peace Treaty of St. Germain in 1919 it became apparent that the defeated Habsburg monarchy had no chance of restoration and that the annexation of Austria by Germany was not possible. In the elections of February 1919, Social Democrats emerged as a strong political power. Nevertheless, realizing that they could not rule alone, they were forced to form a coalition government with the conservative Christian Socials.[7] During the country's transformation from an empire to a state republic, Austrians suffered from scarcity of food and fuel, from an epidemic of the "Spanish grippe," which killed thousands, and from critical housing shortage. The Viennese streets were occupied either by the returning soldiers, the indignant workers on strike, or the refugees coming from the former monarchy, especially those Jews who fled from Galicia during the war.[8] As it turned out the only promising political force that had the ability to curb and manipulate the power of the unemployed workers and radical crowds was the Social Democrats. While the SDAP controlled the capital and the industrial areas, the Christian Social Party dominated the provinces and the rural villages.[9]

With the war over, the elections of February 1919 clearly marked a shift from a defeated monarchy to a parliamentary state and the emergence of Social Democrats as the strongest party in Austria. They attempted not only to safeguard the parliament from the Christian Socials but also to see to it that Vienna was not going to be the Moscow of Central Europe. As Helmut Gruber argues, "no person of prominence in

[6] Gehmacher, "Men, Women, and the Community Borders," (1998), p. 205.
[7] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 23.
[8] Gruber, *Red Vienna,* (1991); Rabinbach, *The Crisis of Austrian Socialism,* (1983).
[9] For the role of Social Democrats in the Austrian provinces see Jeffery, *Social Democracy in the Austrian Provinces,* (1995).

the SDAP wanted to follow in the Russian Bolsheviks' footsteps."[10] The Communist party, founded in November 1918, was able to capture only five percent of the votes in the February elections. When in mid-April communists rushed to proclaim a republic of soviets in Austria, the *Volkswehr*, a republican army organized by socialists foiled their attempt in front of the Parliament building.[11] The same month, having conceived a reform strategy towards the democratization of the Austrian society, Otto Bauer, a key figure in the SDAP, set up and headed the Socialization Commission. Between mid-March and August the commission put forward a number of radical laws, envisioning a step-by-step socialization of production and a different social and cultural role for workers. A second coalition at the end of 1919, with slight differences in the parliamentary composition gave the socialists the time to put forward further reforms in education and the military.

During this second coalition, before it was dissolved in 1920, Social Democrats secured full legal equality of women in the constitution. At least on paper, "all federal citizens are equal before the law. Privileges as a result of birth, sex, rank, class and confession are excluded."[12] Women had already succeeded in gaining the right to vote for the National Assembly in November 1918, when the Austrian republic came into being and a new electoral law was introduced.[13] In December 1918 twelve women entered the Vienna City Council and in March 1919 ten seats in the Provisional National Assembly were occupied by women, comprising 5.9% of the total.[14] In 1920, out of ten women in the parliament, seven were elected with the Social Democrats.[15] Although the legal position of Viennese women was still not fully recognized, as Anderson argues, they enjoyed "an exceptional degree of freedom compared to women in other European countries even before 1918."[16]

At the time, having achieved the two practical goals of the prewar feminist movement, that of the right to vote and to higher education, feminists seemed to have

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[10] Gruber, *Red Vienna,* (1991), p. 20.
[11] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 23. On two more occasions *Volkswehr* defeated the communists when they led demonstrations in Vienna's streets. The decisive one occurred on June 15, 1919, on which occasion there were twenty deaths and a hundred casualties. (Shell, *The Transformation of Austrian Socialism,* (1962), p. 14.) After that the communist party was discredited and dissolved.
[12] Berth, "Die Stellung der Frau im Recht," (1930), p. 96.
[13] Anderson, *Utopian Feminism*, (1992), p. 119.
[14] Kjäer, "Zehn Jahre parlamentarische Frauenarbeit," (1929), p. 2.
[15] Fürth, "Geschichte der Frauenstimmrechtsbewegung," (1930), p. 80.
[16] Anderson, *Utopian Feminism,* (1992), p. 121.

lost any motive for further political engagement. The lack of an independent political forum in combination with the support of women's rights by the SDAP prompted many of them to participate at the party's side. In May 1919 the Social Democrats won the municipal elections of the city of Vienna and were guaranteed an absolute majority holding 100 out of 165 seats on the city council.[17] According to Rabinbach, partly "the shift to Socialist hegemony was a result of the extension of the franchise to women and young adults."[18] It is not fortuitous that by 1921 women members of the Viennese SDAP accounted for 26 percent of the total.[19]

During their first three years in power, the socialists set the stage for a radical program of social reforms, aiming to transform the municipal services and provide social welfare. Access to local taxation gave Mayor Jakob Reumann and SDAP the chance to finance three major political projects in the city: public housing, educational reforms, and better welfare services. Yet, as Gruber argues, socialists aimed not only to provide improved health care and education to the working class. Their ultimate goal was to transform the working class culture, to alter the behavior of the workers, and use the city as the party's laboratory for its cultural experiment. The architecture of Red Vienna is an indicative example of this transformation.

The severe housing shortage forced the socialists to relieve the crisis by building new dwellings and improving the living conditions of the Viennese working class. The design and layout of the new buildings embodied communitarian values that the socialists wished to foster. Apartment buildings and complexes were located around a central courtyard. Their interior was characterized by small apartments with two rooms and minimal kitchen and bathroom facilities. Specific architectural structures imposed the party's culture and introduced unique gender relations and roles. The communal laundry and cooking facilities, a central housing office, and meeting rooms for the tenants, and enforced building rules for access to space were intended to provide quasi-private environments. Playgrounds and kindergartens were designed to facilitate women's everyday lives between work and family. Although they were planned to reduce the burden on women, the new apartment buildings kept intact the underling assumption that children's care was a gendered task. The building

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[17] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 27.
[18] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 26.
[19] Gruber, *Red Vienna,* (1991), p. 20.

planners and socialist designers sought to protect a few more traditional values despite their overall attempts to alter women's social position. For example, gender roles within the family became tangible in the managerial structure of communal facilities. In each building there was a laundry supervisor who, besides scheduling the wash days for each family, "kept all but the women out of the washing facility (on the prudish grounds of protecting female modesty)."[20] The gender division of labor within the household was apparent by assignment of the traditional role of housekeepers to women.

Besides using architecture as a way to impose socialist ideology, the Social Democrats adopted a certain discourse on the social role of women. Intelligent, educated, engaged in politics and social life, dressed in unrestraining garments, the Viennese women were expected to be successful professionally and also good mothers and wives.[21] Women in academia, nonetheless, had difficulties in combining both. It is indicative that the most actively engaged women physicists in radioactivity research such as Blau, Rona, Kara-Michailova, and Karlik, chose the role of experimenters over the one of mothers and wives. Although gender relations at the Institute were such that facilitated women's work in the laboratory, gender discourse in Viennese society was changing slowly to accommodate the double role of women as mothers and professionally active.

In Red Vienna popular magazines, the party's newspapers, the trade unions, and the mass media such as cinema and radio constructed the gender discourse of the 1920s, while specific further reforms made it possible for Viennese men and women to endorse it. By equalizing male and female wages, socialists made it possible for women to gain status through their work. The city's social support services, such as nurseries and kindergartens, recognized women's double role as workers and mothers, while birth control and issues of abortion became part of the socialists' program.[22] Nevertheless, as Johanna Gehmacher claims, the intended cultural, economic, and legal changes did not alter women's subordinate social role. "The Social Democratic model of comradeship in gender relations merely covered the increase of women's reproductive tasks within the party's reform program."[23]

[20] Gruber, *Red Vienna,* (1991), p. 63.
[21] Anderson, *Utopian Feminism,* (1992), p. 123.
[22] Gruber, *Red Vienna,* (1991), p. 162.
[23] Gehmacher, "Men, Women, and the Community Borders," (1998), p. 209.

The claim that the socialists' accomplishments in the domain of gender issues were modest and even ineffectual is inaccurate. Although various municipal programs were lacking sensitivity to gender issues in many ways, they provided the framework of a potentially unique political culture that could enable women to shape spaces for themselves in the factory, the laboratory, or the household. The cost was often their motherhood, the overburden by workload, and a lack of personal and intimate life, especially for the women working in academia. The Social Democrats, nevertheless, made it possible for them to enter the academic scene. Despite the constant feminist petitions and political pressure before the First World War, women had still been excluded from several academic institutions. It was the socialist political agenda in education that forced these institutions to accept women as students.

In the academic year 1918/1919, the *Technische Hochschule*, Vienna's Polytechnic, opened its doors to women. The next year twenty women registered as matriculated (*ordentliche*) students and seventeen as non-matriculated (*ausserordentliche*), most of whom chose the field of technical chemistry.[24] In 1919 the faculty of law did likewise, opening up the opportunity to women for the higher civil service, one of the higher status professions.[25] Additional reforms secured girls' entrance to boys' secondary schools and the state undertook girls' secondary education.[26] From 1919 to 1934 the number of women attending university studies was exceptionally high compared to the number of male students (see table 5.1).[27]

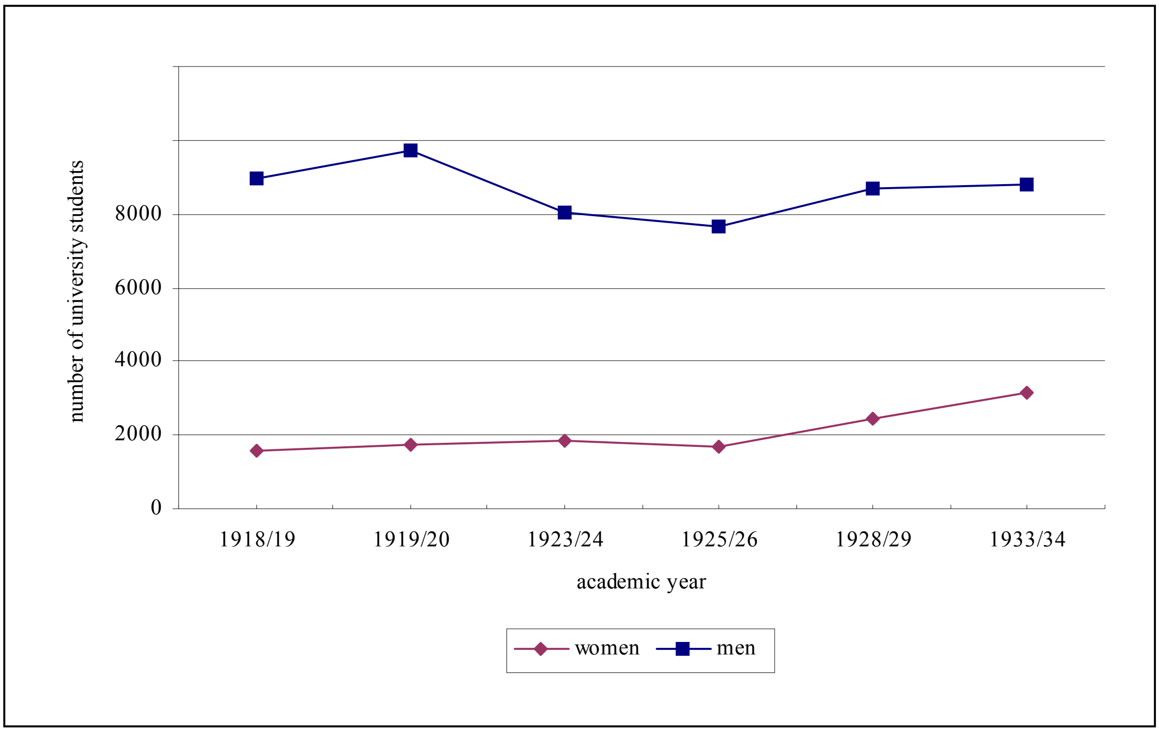
Table 5.1 Enrollment of female and male students, University of Vienna, 1918-1934.

Academic year	Women	Men	Total
1918/19	1569	8946	10515
1919/20	1749	9693	11442
1923/24	1863	8042	9905
1925/26	1669	7631	9300
1928/29	2459	8685	11144
1933/34	3144	8801	11945

[24] Lassmann, Edith. "Das Frauenstudium an den Technischen Hochschulen Wien und Graz", Lassmann file, IAWA. See also Seidler, "Das Frauenstudium," (1927), p. 18.
[25] Heindl, "Zur Entwicklung," (1993), p. 17.
[26] Anderson, *Utopian Feminism,* (1992), p. 120.
[27] The figures in this table are based on Renate Tuma's work on the Austrian women students in the University of Vienna (Tuma, "Die österreichischen Studentinnen," (1993), p. 81).

While during the academic year right after the First World War the ratio of women to men was 1: 5.7, by the end of 1933/34 the same ratio increased to 1: 2.8. (see chart 5.1).

Chart 5.1 Increase in the enrollment of female and male students at the University of Vienna, 1918-1934.



As the next table indicates, the study of physics and chemistry was among the most favored fields at the University of Vienna (see table 5.2).[28]

[28] The figures in this table are based on Renate Tuma's work on the Austrian women students in the University of Vienna (Tuma, "Die österreichischen Studentinnen" (1993), p. 88).

Table 5.2 Number of women enrolled in the philosophical faculty of the University of Vienna by field, 1918-1934

Fields	**1918/19**	**1928/29**	**1933/34**
Philosophy	432	402	383
Psychology	122	424	431
German Philology	255	479	618
Pedagogy	51	357	404
History	218	176	323
History of Art	193	180	160
Physics	172	236	318
Chemistry	223	307	365

The substantial increase of women's percentage to university studies during the 1920s, as Probst argues, came as a result of the reforms of the workers and feminist movements of Red Vienna.[29] What is also striking is the role of the academic community of the *Mediziner-Viertel* in that ongoing construction of gender.

5.2. The *Mediziner-Viertel* During Red Vienna

During Red Vienna and within the boundaries of the *Mediziner-Viertel,* pioneer academic endeavors and the emergence of new scientific fields benefited from municipal support. For example, as Sheldon Gardner and Gwendolyn Stevens argue, many of Vienna's psychologists were social activists and, in turn, psychology was highly supported by the city. Interestingly enough, "Viennese psychology revolved around the university; even the private mental health practitioners sought the prestige that accompanied academic affiliation."[30] The demand of the Social Democrats for new educational methods led to institutional support of the psychological development of children. In 1922 the Social Democrat Undersecretary of Education, Otto Glöckel, offered to the psychologist Karl Bühler one of the philosophy chairs at the University of Vienna. The luck of a specialized institute on psychology led the negotiations to failure. At that point the city of Vienna intervened

[29] Probst, "Emigration und Exil" (1987), p. 468.

by offering a municipal institution that was devoted to advancing teachers training, to be used as a University Institute on psychology. The agreement led to the establishment of the *Pädagogische Institut* under the auspices of the city of Vienna in 1923.[31] Additionally the welfare policies of Red Vienna soon founded a Center for Children in the ninth district, in the *Mediziner-Viertel*, which was led by Charlotte Bühler. That provided the institutional space for Charlotte to advance her practical studies on children's psychology.[32] As Gerhard Benetka argues, "The decision to involve academic psychology in teaching training at the municipal Institute of Education resulted in bringing many young and committed educationalists to the Institute of Psychology."[33] Among them a number of prominent women such as Marie Jahoda, Edith Weisskopf, Else Frenkel-Brunswik, and Editha Sterba entered the field and worked at the Institute.[34]

Psychoanalysis was another attractive scientific enterprise for women during Red Vienna. An "enthusiastic group of young rebels," as Dora Hartmann, the wife of the analyst Heinz Hartmann, characterized the psychoanalysts, founding the Psychoanalytic Society in 1922.[35] By 1931 the membership of the society listed thirty-nine men and nineteen women; one third of the participants were actually women.[36] Freud's daughter, Anna, was the secretary of the Vienna Society and the International Psychoanalytic Society.[37] In the meantime, a member of the society, Helene Deutsch, was instrumental in establishing the *Wien Lehrinstitut*, a center for training analysts. When the institute opened in 1925, Deutsch was named its director and maintained her position until 1933 when she immigrated to the United States.[38] In 1927 in an effort to support the psychoanalytic society, the municipal principals offered Freud a plot of land at Berggasse in the *Mediziner-Viertel,* to build an institute and house the society.[39] The offer was turned down due to the lack of additional

[30] Gardner and Stevens, *Red Vienna and the Golden Age of Psychology,* (1992), p. 2.
[31] Benetka, "The Vienna Institute of Psychology," (1995), p. 128.
[32] Benetka, "The Vienna Institute of Psychology," (1995), p. 130.
[33] Benetka, "The Vienna Institute of Psychology," (1995), p. 128.
[34] Gardner and Stevens, *Red Vienna and the Golden Age of Psychology,* (1992).
[35] Mühlleitner and Reichmayr, "The Exodus of Psychoanalysts from Vienna," (1995), p. 98.
[36] Mühlleitner and Reichmayr ,"The Exodus of Psychoanalysts from Vienna," (1995), p. 98.
[37] Gardner and Stevens, *Red Vienna and the Golden Age of Psychology,* (1992), p. 10.
[38] Gardner and Stevens, *Red Vienna and the Golden Age of Psychology,* (1992), p. 172-4.
[39] Gardner and Stevens, *Red Vienna and the Golden Age of Psychology,* (1992), p. 126.

financial sources. Nevertheless, the society was finally housed at Freud's office on the same street.[40]

Another institute, this time a research center for experimental biology known as the *Vivarium,* is worth noticing for the number of women who worked there during Red Vienna. From 1920 to 1934 there were thirty-nine women out of 109 scientists who listed either as research students or personnel. The high percentage of women at the institute, 36%, does not come as a surprise. "Many Jewish, liberal and social scientists," as Ute Deichmann mentions, "worked at the *Vivarium*."[41] Only few of them had positions at the University of Vienna.

The *Vivarium* was founded on the basis of a private initiative. In 1903 the zoologist Hans Przibram, in collaboration to the botanists Wilhelm Figdor and Leopold von Portheim, purchased a bankrupt show-aquarium in the Prater, Vienna's entertainment park, and turned it to an institute for experimental biology.[42] Hans Przibram, the brother of Karl Przibram, belonged to the Jewish bourgeoisie. Hans Przibram's role was decisive in supporting women's participation at his Institute. The zoologist Leonore Brecher, one of his students, completed her habilitation in 1923 and during the two last years of her study she was appointed as Przibram's private *Assistentin*.[43] In 1925 the opportunity arose to appoint an *Assistent* as a state employ at the Institute, but Brecher had already received a fellowship from the *Deutsches Notgemeinschaft* to spend research time at the Rhoda Erdmann Institute in Berlin. Her colleague, Paul Weiss, was finally appointed instead.[44] Brecher's list of publications is notable during the five years she remained at the Biological Institute. Other women who did research at the *Vivarium* were the botanists Rosi Jahoda and Helene Jacobi, the zoologist Auguste Jellinek, and the botanist Irma Pisk-Felber.[45]

All the above institutes were either promoted by the municipality of Vienna or were privately established. The political agenda and the personal ideology of those

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[40] Janik and Veigl, *Wittgenstein in Vienna,* (1998), p. 21.
[41] Deichmann, *Biologists Under Hitler,* (1996), p. 18.
[42] Koestler, *The Case of the Midwife Toad,* (1971), p. 22; Reiter, "Zerstört und vergessen," (1999), p. 586. During the 1920s one of the *Vivarium's* collaborators, the *Privatdozent* Paul Kammerer, got involved in a controversy with a Cambridge academic, William Bateson. The dispute on the existence of the nuptial pads of the midwife toad eventually, as Koestler argues, had a fatal outcome. Kammerer committed suicide in 1926. For an account of the episode see Koestler, *The Case of the Midwife Toad,* (1971).
[43] Leonore Brecher, Rigorosenblatt, AÖAW.
[44] Hans Przibram to Exner, November 5, 1925. AÖAW.
[45] Almanach, Akademie der Wissenschaften in Wien, for the years from 1920 to 1934, AÖAW.

who founded them seem to have played a crucial role in accepting a large number of women. As a means to understand the status quo of post-war Vienna and a way to change it, socialists such as the party leader Otto Bauer, the Undersecretary of Education Otto Glöckel, and the philosopher Otto Neurath regarded science and education as a crucial component of their socialist cultural experiment. Thus, they provided the epistemic framework and the political power for social transformations. Among those was the active participation of women in academia.

Neurath emphasized the importance of economics and natural sciences to the socialist program through his involvement with the *Vienna Circle,* the philosophical group of logical positivists, the socialist housing project, and the creation of a museum of economics in Vienna.[46] His strong political activity in the circles of Social Democrats and his connections to the scientists and philosophers of the *Vienna Circle* shed light on the engagement of philosophical circles with the politics and culture of Red Vienna. With his fellow students Philip Frank, Hans Hahn, and Olga Hahn, Neurath shared an interest in new trends in theoretical physics, mathematics, logic, and philosophy. In 1922 the mathematician Moritz Schlick was appointed to Ernst Mach's former chair at the University of Vienna.[47] Beginning in 1924, with Schlick's initiative, the *Vienna Circle* started to meet regularly and discuss their philosophical interests. The aim of the group was to achieve a science free of metaphysical claims. Their gathering point for every Thursday-evening meeting was a small lecture room at the Physics Institute at Boltzmangasse 5 next to the Radium Institute.[48] Loyal to the Viennese coffeehouse culture, the group continued the meetings in the Café Herrenhof, next to the Mathematics Institute, which was owned by Walter Mayer, one of the mathematicians participating in the group's discussions.[49]

Although it is not widely known, the *Vienna Circle* included a few women. One of the first to participate in Thursday meetings was Olga Hahn. Despite the fact she was blind, Hahn studied mathematics at the University of Vienna with the help of Otto Neurath and his first wife, Anna Schapire. In 1912, after Anna's death, Neurath married Olga. Her brother Hans introduced both Neurath and Olga to the Thursday

[46] For Neurath's political engagement and philosophy see Cartwright et all., *Otto Neurath,* (1996), pp. 56-82. For the cultural links between Neurath's and Vienna Circle's philosophical positioning and the Bauhaus architecture of Red Vienna see Galison, "Constructing Modernism," (1996), pp. 17-44.
[47] Cartwright et all., *Otto Neurath,* (1996), p. 77.
[48] Reiter, "Vienna: A Random Walk," (2001), p. 478.

meetings.[50] Another woman, the Viennese mathematician Olga Taussky-Todd, attended the meetings because of her scientific interests. "I was probably the youngest in age there and I did not associate myself with it for the purpose of working in it, but in the expectation of using their ideas to further my mathematical work."[51] Last, Rose Rand, a student of Stefan Meyer and Egon von Schweidler, was actually the only woman whose name was in the protocol-list of the *Vienna Circle* meetings.[52]

The above instances and the participation of women in several academic endeavors are not sufficient to indicate a causal relation between politics and gender in Red Vienna, nor a necessary feminist positioning of women in science during that period. For example, nothing in the tenets of the *Vienna Circle* implies a concern for gender relations or the participation of more women in the group. Clearly there were logical positivists such as Neurath who embraced ideas about women's emancipation, but this is not to argue that the rest of the group had similar concerns. In the case of psychology, a few argue that Charlotte Bühler, although a powerful woman in the field, subscribed to conservative ideas and probably was mildly anti-Semitic.[53] In fact given the feminist criticisms of Freud's theories of femininity that contradict his personal positioning on encouraging women members of the psychoanalytic society, psychoanalysis constitutes a more interesting case.[54] Thus, the evidence is not sufficient to stress causal links between the politics of Red Vienna and the increasing number of women in Viennese academia. Yet, it is indisputable that the social democratic discourse offered women more opportunities to enter academia. Instead of causation, the focus here shifts to correlation between available images, cultural ambiguities, and understandings of sexual difference produced by the socialist discourse. Especially for the case of radioactivity research and the physics community, the educational reforms embraced by the SDAP are reflected in the statistical data concerning the gender politics of employment and the division of labor in the Institute.

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49 Tausky-Todd, "Olga Tausky-Todd: An Autobiographical Essay," (1985), p. 317.
50 Cartwright et all., *Otto Neurath,* (1996) pp. 12-13.
51 Tausky-Todd, "Olga Tausky-Todd: An Autobiographical Essay," (1985), p. 319.
52 Korotin, "Auf Eisigen Firnen," (1997), pp. 301-3. See also Rose Rand's curriculum vitae, RR 2-5-21, AUP.
53 Gardner and Stevens, *Red Vienna and the Golden Age of Psychology,* (1992), p. 150.
54 For example, see Wittig, *The Lesbian Body,* (1976); Butler, *Gender Trouble,* (1990).

5.3. The Transition Period: The Institute for Radium Research in the Early 1920s.

Inside the walls of the Radium Institute post-war politics took on interesting dimensions. Exner's academic politics in the period before the First World War and his affiliation with the Austrian Academy of Sciences enabled physicists to acquire their own quarters, expanding the scope and effectiveness of their research. The Institute became a source of physicists' power in the Habsburg empire and their emblem in the international scientific world. By the end of the war, nevertheless, the transformation of national politics from a monarchy to a republic and the financial deterioration of Austria posed new challenges to the physicists of Vienna. Austria did not include Bohemia anymore, since that part of the old Habsburg Empire, now belonged to Czechoslovakia. Redrawing the political map of the area meant more than demobilizing soldiers and the rearrangement of populations. The cost to the Institute was the loss of their main source of radioactive materials, the St. Joachimstal mines in Bohemia. As Meyer described to Rutherford after the war "Dr. Ulrich was expelled last summer from Joachimstal—of course after the peace and on the beginning from the internal hostilities through the Czechs. He does not know the Czech language and as nobody in Joachimstal speaks it, it was quite unnecessary, but this crime was sufficient to dismiss him."[55] Ulrich remained as a guest at the Institute and continued his work, but the main advantage of the Viennese over the rest of the radioactivity community was gone.[56]

In the years immediately after the end of the First World War, Stefan Meyer was busy finding the financial means to save his Institute, supporting the experimental work of his colleagues, and engaging in academic politics for the sake of his research personnel. Although he was not yet the official director, since the establishment of the Institute Meyer had been acting as the main administrator and the leader of the research carried out in it. In 1920, with Franz Exner's imminent retirement, he seemed about to become his undisputed successor. Surprisingly, in a letter to Rutherford on February 8, 1920, Meyer expressed his worries. The shift in directorship was not an easy issue; it was connected to the relations to the neighboring institutes, the political

[55] Meyer to Rutherford, January 22, 1920, AÖAW, (in English).
[56] Meyer, "Das erste Jahrezehnt" (1920), p. 11.

situation in Austria, and the culture of physics that Meyer wanted to establish in Vienna.

> Professor Exner is now 71 years old and will leave his institute soon. We want his successor to give lectures on experimental physics based on theoretical foundations in courses of 2 years. The best men, I think, we can get for the post are Jäger or Schweidler or Mache or Benndorf. Personally I myself do not want to be in the combination as long as one of these gentlemen, to whom all I am in terms of heartily friendship, are possibly to get for the charge. Now there is also Ehrenhaft, who pushes himself forward in a very intrusive way and who has some acquaintance in the momentary reigning government, who sustain his candidature. I would be very much obliged to you, if you would write me as soon as possible your opinion on the works of Ehrenhaft and if there is anybody in England who believes in his "subelectrons". I cannot deny that I do not sympathize neither with his scientific way nor with his personage; but as I am not willing to be guided by my own prejudices, I would be very pleased to have your objective judgement. [57]

Rutherford's response came a few days later. He did not find Ehrenhaft's scientific work convincing but could not comment on his personality. As he mentioned, he had no acquaintance with him. He was definitely surprised, as he "always supposed he [Ehrenhaft] was one of the band connected with the Radium Institute."[58]

Indeed Felix Ehrenhaft was one of Exner's students. The son of a physician, he was born in 1879 in Vienna. He studied physics with Exner and in 1904 he became an *Assistent* at the first Physics Institute under Victor von Lang.[59] His main focus was on theoretical physics and, with Exner's retirement, Ehrenhaft envisioned himself as his successor, utilizing some political connections. Meyer's main concern, on the other hand, was to sustain the experimental research at the Radium Institute. Besides ensuring that Exner's successor would be able to teach and so favor experimental physics, Meyer needed the connections to the Physics Institute for practical reasons. The use of instruments and library resources was essential for the research at his institute. As it turned out the issue was finally resolved by political intervention, since Exner's retirement resulted in the reorganization of the physics institutes. Instead of becoming the director of the second Physics Institute, on October 1, 1920, Ehrenhaft

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[57] Meyer to Rutherford, February 8, 1920, M191, CUL, (in English)
[58] Rutherford to Meyer, February 18, 1920, AÖAW.

was appointed head of the newly established third Physics Institute, focused on general physics.[60] The same year Gustav Jäger, one of Meyer's close collaborators, succeeded Exner in the directorship of the second Physics Institute while Meyer was officially named the director of the Radium Institute.[61]

The time was difficult indeed for both the country and the Institute. As Meyer wrote to Rutherford, "The so called peace has aggravated the difficulties enormously and I fear, we will not be able to continue scientific work, if at all we may continue our life."[62] Inflation was out of control, the Austrian currency had only the 2% of its previous value, and food and energy sources were in short supply. During that time, the Radium Institute faced significant problems. The old staff and key figures at the Institute before the First World War were now scattered. Otto Hönigschmid had moved to the University of Munich, Fritz Paneth became a professor at the University of Hamburg, Stephanie Horovitz left for Warsaw, and Georg von Hevesy was in Budapest. Meyer's Institute could not afford the most prestigious science journals.[63] Without knowledge of the foreign literature, research became problematic. In January of 1921 the situation deteriorated. "I fear," wrote Meyer to Rutherford, that "scientific working comes here to an ending if there will be no help till now not foreseen. Our dotation pro year is 2000 Kronen, which values at the moment less than 1pound. It is quite impossible to go on such conditions and the academic people who had interests in scientific work is now reduced to poverty and not be able to sustain the institutes."[64] As a temporary solution, after Meyer's kind request, Rutherford arranged to purchase the radium that was lent to him before the war by the Austrian Academy. By the end of the year Meyer received a check for over 500 pounds, which contributed to the ongoing research at the Institute and relieved temporarily its financial problems.[65] Additionally, some of the Institute's international friends provided the Institute's library with subscriptions to *Nature, Philosophical Magazine,*

[59] Karlik and Schmid, *Franz Serafin Exner,* (1982), p. 144.
[60] Hittner*, Geschichte des Studienfaches,* (1947), p. 77.
[61] Almanach, Akademie der Wissenschaften in Wien, (1920), p. 180, AÖAW.
[62] Meyer to Rutherford, January 22, 1920, AÖAW, (in English).
[63] Meyer to Rutherford, January 22, 1920, AÖAW.
[64] Meyer to Rutherford, January 12, 1921, AÖAW (in English).
[65] Rutherford to Meyer, July 25, 1921, AÖAW; Rutherford to Meyer, October 17, 1921, AÖAW; Rona, *How it Came About,* (1976), p. 21-22.

and a number of the other prominent scientific journals necessary for keeping up research at the Institute.[66]

Unexpectedly, in 1921 Meyer received a letter from the Swedish physicist Hans Pettersson asking for permission to use the facilities of the Institute for his own research.[67] It could have been one of those regular requests that Meyer used to receive from all over the world given the fame and the high quality facilities of the Institute. However, over the next years Pettersson brought his own equipment and finances to the Institute, organizing and supporting a research team of young collaborators working on artificial disintegration—the transmutation of one element to another by bombardment of alpha particles and the emission of long-range particles. Regular flow of money from Swedish sponsors that only Pettersson could enlist, and also from the Rockefeller Foundation, secured research until the end of 1928. In short, Pettersson transformed the experimental culture of the Institute, provided positions for new personnel, and established the Institute as the major competitor of Rutherford's research laboratory in Cambridge.

Introducing this new research program required changes in space arrangements, the use of new experimental techniques, and the reordering of the entire laboratory. Pettersson brought a new era of experimentation to the Institute. The need for specialized personnel led a considerable number of women, his wife Dagmar Pettersson among them, to engage in radioactivity, elevating the Radium Institute to what Galison called a "mecca" for women working on radioactivity research.[68] During the 1920s enthusiastic young researchers such as Ewald Schmidt, Max Kindinger, Blau, Rona, Karlik, and Kara-Michailova formed a closely connected research group and boosted the Institute to one of the most prestigious radioactivity centers in Europe. A number of women doctoral students, such as Hertha Wambacher, Theodora Kautz, Erna Bussecker, Felicitas Weiss-Tessbach, Selma Schneidt, and Elsa Holesch, oriented their research projects around the themes of Pettersson's group.[69]

[66] Almanach, Akademie der Wissenscahften in Wien, (1921), pp. 194-5, AÖAW.
[67] Pettersson to Meyer, November 28, 1921, AÖAW.
[68] Galison, *Image and Logic* (1997), p. 150.
[69] Kautz, "Ermittlung der Halbierungszeit," (1926), pp. 93-97; Kautz studied physics and mathematics at the University of Vienna under Meyer and Gustav Jäger, and graduated in 1926 (Kautz Theodora, Rigorosentakt 9216, AUW.) She left the Institute to become schoolteacher. Meyer kept in touch with her and in 1934 he informed her that the granddaughter of the president of the Academy, Eduard Suess, was her student (Meyer to Kautz, May 11, 1934, AÖAW); Bussecker, "Verflüchtigungskurven," (1928), pp. 117-126; Bussecker graduated in 1929 after studying physics and mathematics under Meyer

When Meyer received Pettersson's letter, he could not have envisioned the drastic changes that the young physicist was going to bring to the Institute. Friendly and hospitable as usual, he posted the note, "willkomen," on the upper corner of Pettersson's letter, welcoming the chance of having one more international colleague on his staff. Shortly after, Hans and Dagmar Pettersson blended very nicely into Viennese culture and felt at home with the ethos of doing physics at the Institute.

5.4. Stefan Meyer as Mentor and Political Figure

As the Rayner-Canhams argue, one of the reasons women chose to enter the field of radioactivity was "the presence of supportive supervisors who acted as mentors for them."[70] Ruth Sime makes a persuasive case for Lise Meitner who was introduced to the field by Meyer in the early days of radioactivity.[71] Elisabeth Rona adds her own experience to the same picture. In early 1913 she chose to work with Kasimir Fajans on radioactivity instead of Georg Bredig on physical chemistry because the latter was an "autocratic German professor," a model that hopefully Fajans did not fit.[72] Her second experience working in the field, an "exciting and pleasant" one, was with Georg Hevesy in Budapest. Rona was free to use her own imagination in her research and described Hevesy as someone who "did not feel the need to keep his students in their place."[73] At the Kaiser Wilhelm Institute in Berlin-Dahlem, Rona felt also at home with Otto Hahn and Lise Meitner, "fortunate to work in such a stimulating environment." [74] She spent almost two years, starting in 1921, at the radioactivity department.

Indeed, Meyer as director of the Radium Institute and supportive supervisor and mentor, played a decisive role for the entrance of a number of women to the field. He primarily supplied the tone and shaped the working ethos at his institute. In his obituary of Meyer, Robert Lawson recalls his "personal charm and good nature, his

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and Gustav Jäger as well (Bussecker Erna, Rigorosenakt 10210, AUW); Weiss-Tessbach, "Mikrokalorimetrische," (1928); Schneidt, "Das Electrochemische Verhalten," (1929), pp. 755-765; Schneidt was bron in Komotan, Bohemia and was a fellow student of Bussecker (Schneidt Selma, Rigorosentakt 10442, AÖAW.); Holesch, "Uber die Vardampfung," (1931), pp. 663-678. Holesch was a student of Meyer and Thirring. She graduated in 1931 (Holesch Elsa, Rigorosenakt 11257, AUW).

[70] Rayner-Canham, M. and Rayner-Canham, G., *A Devotion to their Science,* (1997), p. 18.

[71] Sime, *Lise Meitner,* (1996), p. 18.

[72] Rona, *How it Came About,* (1978), p. 3.

[73] Rona, *How it Came About*, (1978), pp. 8-9.

warm friendship and his innate kindliness."[75] Lawson came to work at Meyer's Institute in the end of 1913 but with the outbreak of the First World War he was trapped in Vienna. When the police harassed him as 'enemy alien,' Meyer came to his aid and kindly offered him research space in his laboratory until the end of the war. "…[Meyer] supplied me with money on trust and free of interest, the amount being left to my discretion, and he established intermediate but adequate contact with my parents."[76] Lawson was not the only one who appreciated Meyer's personality. Paneth described him as "mild, in a few cases too mild critic of the younger generation; but a glance over the titles and authors of the four hundred and fifty-odd *Mitteilungen* published up to now reveal how much fundamental progress in the physics and chemistry of radioactive substances is due to research work carried out in Meyer's Institute."[77] Yet besides his scientific achievements, as Otto Hahn recollects, "he gave every individual far-reaching freedom in his work and allowed him always to publish alone, although for very many investigations he nevertheless was the intellectual stimulus."[78] Certainly his "genuine collegial loyalty" shaped the ethos of working at the Institute.

Meyer, nonetheless, was not encouraging only to his male personnel and students. On several occasions he welcomed international female colleagues and was generously supportive to the women who worked at the Institute. For example, in 1930 Meyer arranged for Karlik to work at William Bragg's laboratory in Cambridge.[79] Out of thirty-two women who appeared as authors in the *Mitteilungen* between 1920 and 1934, twenty entered the Institute as Meyer's students.[80] With

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[74] Rona, *How it Came About,* (1978), p. 10, 13.
[75] Lawson, "Prof. Stefan Meyer," (1950), p. 549.
[76] Lawson, "Prof. Stefan Meyer," (1950), p. 549. In 1919 Lawson moved to Sheffield having developed already close relations with most of his colleagues in Vienna. As Rutherford reported to Meyer in 1920, "Lawson came to see me in Manchester and gave me detailed news of all of you, which I am very glad to hear. Lawson has now got a post in Sheffield and I hope is comfortably situated. He seems a very keen a prolific worker. I appreciate very much the kind way you looked after him in difficult times." (Rutherford to Meyer, January 13, 1920, CUL). In 1918, in collaboration with Hilda Fonovits, Lawson started to work on the number of ion pairs produced by alpha particles of radium C. After he left, she carried the study over without Lawson and presented her paper to the Austrian Academy of Sciences in 1922 (Fonovits, "Die Zahl der von einem a-Teilchen" (1922), p. 356).
[77] Hahn, "Prof. Stefan Meyer," (1950), p. 165.
[78] Reiter, "Stefan Meyer," (2001), p. 119.
[79] Bragg to Meyer, August 29, 1930, AÖAW; Meyer to Bragg, September 1, 1930, AÖAW.
[80] The information comes from the individual Rigorosenblätter of all the women of the Institute that are held in the archives of the University of Vienna.

some of them he kept in touch even after they left the Institute.[81] Throughout his directorship there had been several requests from international women scientists to use the facilities of the Institute. For example in the summer of 1925 Marie Farneworth wrote to Meyer asking his permission to spend six month at the Radium Institute in Vienna. A research chemist working for the United States Bureau of Mines, Farneworth graduated from the University of Chicago. “It is my intention to apply for a Guggenheim fellowship for advanced study abroad for the academic year 1926” as she informed Meyer.[82] Her expertise was on separating protactinium from carnotite. Not surprisingly, standing on the border zone among physics, chemistry, and medicine, Farneworth had worked as a consultant for physicians and hospitals. In his usual manner Meyer posted “willkommen” on the upper corner of her letter.[83] Frances Wick was another physicist, an associate professor at the Vassar College, who asked Meyer to spend some research time in the Institute. Wick graduated from Cornell University in 1908 and was the first woman who worked on airplane radios and gun sights at the United States Army’s Signal Corps in 1918.[84] As the publication records and the almanac of the Austrian Academy show, Wick came to Vienna twice and spent more than two years in the Institute joining Przibram’s research group on radioluminescence.[85] The most indicative example of Meyer’s role in bringing and welcoming women to the Institute is the case of Rona. In the summer of 1925 Meyer, spending his holidays in Bad Ischl, a summer resort in Austria, knocked unexpectedly on Rona’s door and offered her a position in his Institute. Having previously worked with some of the main figures in the community of radioactivity, Rona was already a known physicist. Her later account of Meyer’s personality and his role as a director does not come as a surprise. “The atmosphere at the Institute was most pleasant. We were all members of one family. Each took an interest in the research of the others, offering help in the experiments and ready to exchange ideas. Friendships developed

[81] Meyer to Dora Kautz, May 11, 1934, AÖAW; Meyer to Gertrud Wild, June 17, 1946, AÖAW.
[82]Farneworth to Meyer, July 8, 1925, AÖAW.
[83] Although Meyer responded positively to Farneworth’s request, she probably did not come since her name appears neither in publication records nor in the almanac of the Austrian Academy of Sciences.
[84] Rossiter, *Women Scientists in America,* (1982), p. 118.
[85] In the Almanach, Akademie der Wissenschaften in Wien, for the years 1929/30, 1930/31 and 1936/7 Wick appears as collaborator of the Institute. Also she published two papers during her stay at the Institute. Wick, “Versuche über radiothermolumineszenz,” (1930); Wick, “Über Tribolumineazenz” (1936). During her first visit she suffered a serious infection as well as Franziska Witt and Stefan Wolf, also members of the Institute (Almanach, Akademie der Wissenschaften in Wien, (1930), p. 234).

that have lasted to the present day. The personality of Meyer and that of the associate director, Karl Przibram, had much to do with creating that pleasant atmosphere."[86]

Meyer's role was also crucial in connecting the women of his institute to the key figures of the radioactivity community. For example, his close friend, the Norwegian radiochemist Ellen Gleditsch, paid several visits to the Radium Institute over the years at his invitation. Five years younger than Meyer, Gleditsch was one of the first women who entered the field of radioactivity before the First World War, collaborating closely with Marie Curie.[87] Her scientific and friendly relationship with Meyer goes back to the First World War, when Gleditsch supplied radioactive materials for the research that Horovitz and Hönigschmid were performing at the Institute.[88] Besides spending time at Curie's laboratory in Paris, Gleditsch worked with Bertram Boltwood in his laboratory at Yale University for a short period of time. The exact determination of the half-life of radium brought Gleditsch to the forefront of radioactivity research and established her as a specialist in the separation of radioactive substances from minerals. In 1916 she was appointed *Dozent* at the University of Oslo. Politically aware of the difficulties women face in their scientific careers, Gleditsch became heavily involved in the International Federation of University Women, established in 1919.

Besides the exchanges of publications and even instruments, Meyer and Gleditsch welcomed each other's research students at their institutes.[89] In 1934 Gleditsch arranged for her assistant Ernst Föyn to spend some time in Vienna.[90] Gleditsch's close relations with and welcoming attitude to most of the women at the Radium Institute, such as Blau, Rona, and Karlik, led them to her laboratory during the late 1930s.[91] Visible in the radioactivity community and active in feminist politics,

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86 Rona, *How it Came About,* (1978), p. 15.

87 Unless it is stated otherwise, the biographical information on Gleditsch comes from Weidler Kubanek and Grzegorek, "Ellen Gleditsch," (1997), pp. 51-75.

88 Rayner-Canham, M. and Rayner-Canham, G., "Stefanie Horovits," (1997), p. 194.

89 In 1919 Gleditsch thanked Meyer for sending her his valuable papers and expressed hope to visit the Institute in the future (Gleditsch to Meyer, April 27, 1919. AÖAW). In a letter to Gleditsch, Karlik assures her that she sent a microscope table, which should arrive soon in the mail (Karlik to Gleditsch, April 7, 1938, AÖAW).

90 Meyer to Gleditsch, August 18, 1934, AÖAW; Gleditsch to Meyer, August 30, 1934, AÖAW.

91 As the Rayner-Canhams argue, Gleditsch is the most overlooked person in the history of women in radioactivity as she was the one who linked all of the different research groups together. Besides working and corresponding with all the key figures in the field, Gleditsch played a crucial role providing shelter in her laboratory to many of the women who had to flee Vienna in 1938 (Rayner-Canham, M. and Rayner-Canham, G., *A Devotion to Their Science,* (1997), p. 27).

Gleditsch functioned as mentor for many of the younger women in the field, paying attention not only to their scientific work but to their personal lives as well. For example, in 1934, being older and more experienced, Gleditsch warned Rona of the radioactivity hazards. “My dear Elisabeth pay attention before it is too late,” she urged.[92] Appreciating the warm friendship, Karlik took care of Gleditsch when she visited Vienna to spent time at the Institute in the late 1937.[93] Meyer’s role in supporting all those contacts was instrumental.

Creating a stable and welcoming space for women in the laboratory has never been a one-way process. Women’s personal ambitions and support from mentors and supervisors are not enough for their presence in a laboratory. The political context plays a crucial role as well. In the case of the Viennese Institute, Meyer was indeed one of the kindest and most well-respected persons in the scientific community. He was not only kind and generous but, most important, he was politically engaged. His connections to Julius Tandler, ensured the Institute’s preeminence in the scientific community of the city and the financing of some of his personnel. At the same time, Tandler’s effort to reshape the public health and welfare system of Vienna put his ties to the physics and medical community of the *Mediziner-Viertel* to use, giving Meyer and his institute the chance to play a key role in the socialist reforms. Both Tandler and Meyer were indispensable to one another for the sake of their own political agendas.

Tandler was a prominent anatomist and one of the few Jews with a chair at the medical faculty of the University.[94] He entered the University of Vienna in 1889 as a student of medicine and, after his graduation in 1895 he was hired as *Assistent* at the I Anatomical Institute. His connections to physicists went back to the year that Franz Exner reported the discovery of x-rays to the medical society. As a young, enthusiastic doctor, Tandler was the one who provided Exner a hand of a cadaver from the anatomical institute to perform his first x-ray experiments.[95] In 1910 Tandler was promoted to *ordinarius Professor* of anatomy and from 1914 to 1917 served as

[92] Gleditsch to Rona, August 19, 1934, AÖAW.
[93] Gleditsch to Karlik, May 4, 1937, AÖAW.
[94] Sablik, *Julius Tandler*, (1983).
[95] Mould, *A Century of X-Rays,* (1993), p. 83.

the dean of the medical faculty.[96] His inside knowledge of the medical system of Vienna and his strong socialist ideology served as the most suitable guide for the Social Democratic reforms in public health and welfare system after the end of the First World War. With his appointment as the city councilor of welfare in 1920, Tandler was able to reshape the medical clinics and general hospital at the *Mediziner-Viertel* and Vienna in general. An enlarged budget was essential to improving the quality of services and making them accessible to all citizens.[97]

In his socialist program Tandler included the promotion of new scientific methods in medicine such as the use of radium. In 1929 he asked Meyer to provide 5gr radium to the municipal hospital in Lainz, envisioning a more ambitious project such as the establishment of a radium station and a pavilion for cancer therapy.[98] Hoping to gain from the long experience of French physicians, Tandler visited Paris twice.[99] During the summer of 1930 he arranged his next visit to the *Radiumhemmet* in Stockholm, one of the best centers for radium therapy in Europe.[100] A few months later, on December 20, 1930 in a city meeting at the *Rathaus*, Tandler was ready to promote his plan.[101] For this ambitious and costly endeavor he depended heavily on Meyer's help. With Tandler in the position of the councilor for welfare, Meyer and his Institute were able to play an important role in the shaping of socialist projects. As Emil Maier, a physician at the hospital in Lainz, informed his colleagues in Stockholm, Meyer and his personnel at the Radium Institute offered not only to provide the radium but also to build a "radium gun," a device with strong radium preparation used in cancer therapy.[102] Furthermore, "The consulate of the municipality of Vienna for the radium purchase is Herr Professor Stefan Meyer."[103] With the support of the municipality, beginning on December 1, 1930, Maier spent half year between Stockholm, Paris, and Brussels in order to get trained in the new

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[96] During the war the use of x-rays in examining wounded soldiers was one of the most important medical achievements. In a makeshift hospital, Tandler built in a roentgen tube under the operating table in order to perform brain surgeries and remove bullets. His team physicians included the radiologist Guido Holzknecht, the neurologist Otto Marburg, the neurosurgeon Egon Ranzi, and the surgeon Anton Freiherr von Eiselsberg (Angetter, *Guido Holzknecht* (1998), p. 55).
[97] Gruber, *Red Vienna,* (1991), pp. 65-73.
[98] Meyer, "Die Vorgeschichte," (1950), p. 20; Alth, *50 Jahre Strahlentherapie,* (1981), p. 12.
[99] Alth, *50 Jahre Strahlentherapie,* (1981), p. 13.
[100] Gard to Maier, August 8, 1930, AHL.
[101] Tandler to Ahlboom, December 20, 1930, AHL.
[102] Maier to the Radiumhemmet, December 30, 1930, AHL.
[103] Maier to Ahlboom, January 3, 1931, AHL.

radium therapy methods.[104] Eventually, the pavilion for radium therapy opened up in 1931 and a year later the radium station was established.[105] Known as the *Physikalische Laboratorium am Strahlen-Institut*, the radium station functioned as the point of entry to the field of radium therapy for two of the Radium Institute's collaborators.[106] Franz Urbach directed the *Physikalische Laboratorium* and worked on radium dosimetry and instrumentation from 1932 to 1934, when Hilda Fonovits-Smereker succeeded him.[107] Meyer, through his connections to Tandler and the physicians at the hospital in Lainz, offered both of them the chance to cross the border of physics to medicine, carrying over their expertise in instrumentation and experimentation from the Radium Institute to the municipal hospital.

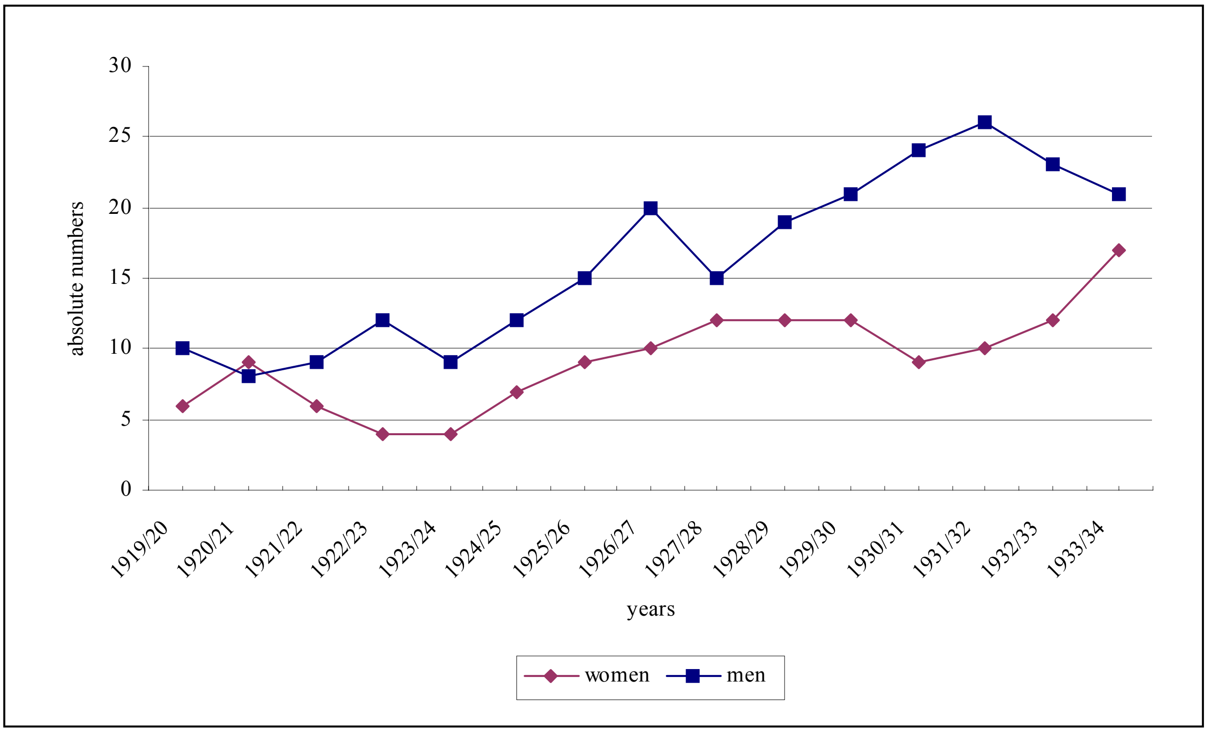
Last, besides being very sympathetic to Social Democratic ideas, the fact that Meyer was Jewish in an anti-Semitic city offered him a distinct standpoint in his life. As Gruber argues, anti-Semitism was deeply rooted in Austrian society even during the years of Red Vienna. "It is the Viennese Jews prominent in professions and arts, in journalism and the rising mass media. In industry and high finance, but especially in SDAP, who were the target in the hate campaigns which were a permanent fixture of the First Republic."[108] Being Jewish and a woman was the worst combination for hiring and promotion in the University of Vienna. When, for example, Blau attempted to get a position as *Dozentin* at the University, the response was, "you are a woman and a Jew and together this is too much."[109] For those women who wished to remain in academia it was clearly a disadvantage to be Jewish.[110] In Meyer's Institute that was not the case. During his directorship, Meyer did not seem to have discriminated against women nor, of course, against Jews. As the gender profile of the Institute shows, a few of the most engaged women in radioactivity research were Jewish.

[104] Emil Maier, Lebenslauf, undated in Maier, Rigorosenakt, p. 6, AUW.
[105] Alth, *50 Jahre Strahlentherapie* (1981), p. 12; Kogelnik, "The History and Evolution of Radiotherapy" (1996), p. 224; With the absolute support of the SDAP and the city's mayor, Karl Seitz, Tandler also established a new pavilion for the cure of tuberculosis with 300 beds and modern facilities at the municipal hospital. At the time, tuberculosis was considered the "Viennese disease" given the exceptionally high numbers of patients (Luger, *70 Jahre Krankenhaus der Stadt Wien-Lainz,* (1977), p. 3).
[106] Urbach, "Einiges aus dem Physikalischen Laboratorium," (1933), p. 537-541.
[107] Urbach, "Einiges aus dem Physikalischen Laboratorium," (1933), p. 537-541; Reiter, "The Year 1938," (1995), p. 198-99. Meyer, "Die Vorgeschichte," (1950), p. 20. Bischof, *Frauen am Wiener Institut,* (2000), p. 67.
[108] Gruber, *Red Vienna,* (1991), p. 26.
[109] Halpern, "Marietta Blau," (1997), p. 197.
[110] Freidenreich, "Gender, Identity, and Community," (1998), p. 166.

5.5. The Gender Profile of the Institute, 1919 – 1934

The almanac of the Austrian Academy of Sciences from 1919 to 1934 serves as a starting place and an indicator of the number of women and men at the Radium Institute. A survey of the annual reports of the Institute written by the director and published at the almanac reveals that the percentage of women working at the Institute was exceptionally high, 38%. Out of 113 scientists who used the facilities of the Institute and were working towards their *Praktikum* or were actually employed by the Institute, 43 were women. When these data are broken down by gender over the fifteen years from 1919/20 to 1933/34 they interestingly reflect part of the Institute's history. From 1923/24 to 1929/30 the number of both men and women increased. The young researchers who entered the Institute in that period were mainly affiliated with Pettersson's team. As soon as he left Vienna at the end of the 1920s, their number dropped, given the lack of funding and the disruption of the Institute's research agenda.

Chart 5.2 Men and Women Working at the Institute for Radium Research



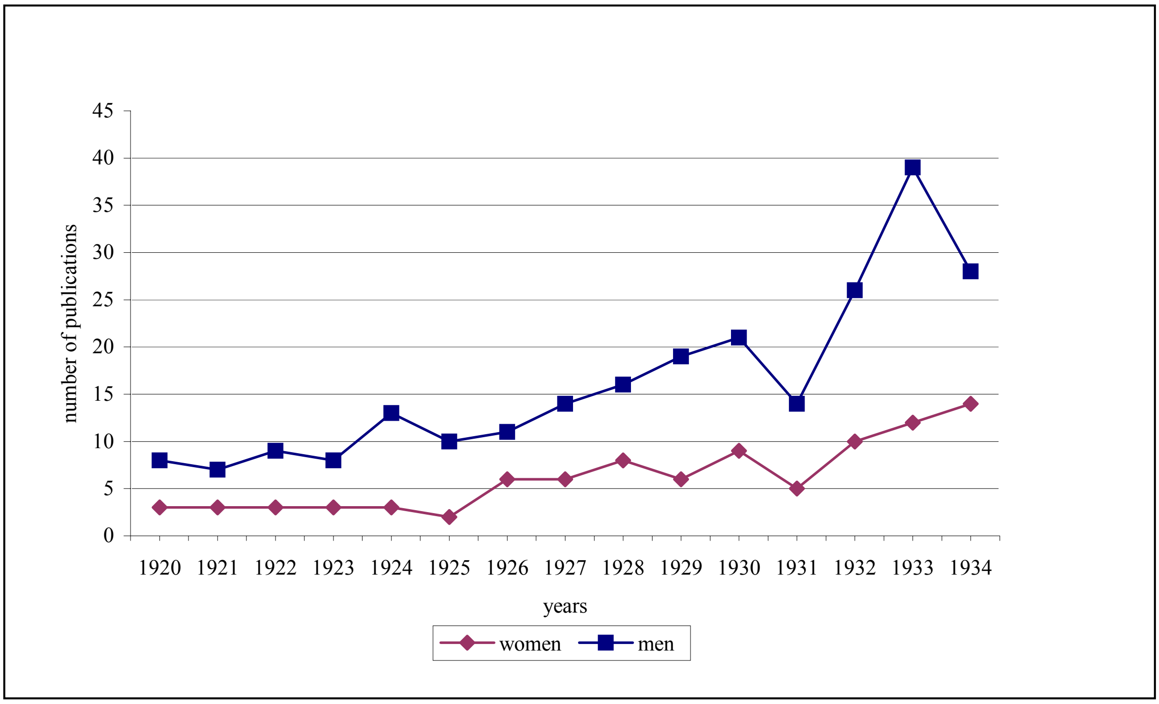
The survey of the *Mitteilungen* reflects the gender division of labor and the level of participation of men and women in the ongoing scientific research. From 1920 to 1934, out of ninety-six individual authors that appeared in the *Mitteilungen,* thirty-two were women. The surprising element is that having an remarkably high percentage of authors, 33%, women were not meticulous assistants and members of the laboratory support staff, preparing the experimental settings for their male colleagues. Comparing the number of women at the Institute over fourteen years to the number of those who published their work during the same period, it becomes obvious that 74% of women were experimenters. The women who actually published in the *Mitteilungen* can be divided by age into two groups. The older generation who were born before the turn of the century (eight out of thirty) had to overcome many educational obstacles. Most of them had private education and belonged to the Viennese upper class. Blau, for example, studied at the private *Mädchen Obergymansium*[111] While education for women became more socially accepted and widespread in the inter-war years, women came from less affluent families.[112]

The list of publications from 1920 to 1934 further reveals that women in the Institute performed their own research and published on their own projects. An analysis of the number of publications per year from 1920 to 1934 demonstrates that women made consistent and steady contributions to the work of the Institute and were as scientifically productive as their male colleagues.

[111] Blau Marietta, Rigorosenakt no 4557, AUW.

[112] These data are based on biographical information included in the Rigorosenakt, (University of Vienna) of the women scientists who did research at the Institute. From these Dagmar Pettersson and Elisabeth Rona are excluded. Among the best gymnasiums from were women graduated, was the private *Mädchen Obergymansium.* Hertha Wambacher, who entered the Institute in the 1930s attended this school as Blau did some years before her (Wambacher Hertha, Rigorosenakt, no 10860, AUW).

Chart 5.3 Number of Publications of Men and Women Working at the Institute for Radium Research, 1920-1934



As the above chart indicates, the number of publications by women rose in a fairly similar way as men's. Especially from 1925 to 1930, a period that coincides with Pettersson's presence in the Institute, both men and women increased their scientific productivity. The numbers decreased with Pettersson's departure to Sweden at the end of the 1920s. Although for women the numbers slowly rose again after 1932, for men the increase was more rapid. One way to explain this steep increase in the number of publications for men is the fact that at the time Przibram's research on radioluminescence and photoluminescence was at its peak. From 1932 to 1933 he published 11 papers.

When we correlate the number of publications to individual authors, we find that most of the women, twenty-seven out of thirty-two, published either one or two papers. Those women were mainly doctoral students who used the facilities of the Institute towards the completion of their degree and their *Praktikum.* The same holds for men. Out of sixty-four men that appeared as authors in the *Mitteilungen,* fifty published either one or two papers. The status of research students was unique. The Institute was exclusively a research center with no students attending classes within its walls or receiving general practical training in physics. Those who did enter the Institute's doors mainly in the later years of their studies were dedicated to work on radioactivity. As they were fewer comparatively to the students who entered the neighboring physics institutes, they were able to form close working relations to their advisors and mentors.

It is indicative that in the early years many of the young women students collaborated with mature male researchers of the Institute. For example, during the academic year 1919/20, Maria Hornyak was working under Meyer's supervision on the ionisation of alpha rays in different gasses.[113] It was known that the number of ions produced in the path of alpha particles varies with different gases. While Hornyak was still a student she teamed up with Victor Hess to further her research on alpha particles emitted specifically from polonium. Their co-authored article appeared in the *Mitteilungen* in 1920.[114] Hess was already well-known for the discovery in 1912 of cosmic radiation.[115] Hornyak's collaboration with him was interrupted when the he left the Institute in 1920 to accept the position of *Extraordinarius Professor* at the University of Graz. A year later he moved to the United States as director of the U.S. Radium Corporation in Orange, New Jersey.[116] Hornyak remained at the Institute for one more year and in the next edition of the *Mitteilungen,* she presented a study on surface ionisation. Her work was based both on Hess's earlier studies on ion wind produced closed to radioactive substances and an article by Hilda Fonovits on the attainment of saturation currents for alpha rays.[117] More generally, the stereotype of a male mentor and a female student broke down in the mid-1920s, when women such as Kara-Michailova, Blau, Rona, and Karlik gained status in the Institute and participated in the core research groups of the Institute.

The correlation of the number of publications to individual authors reveals that from 1920 to 1934 only the above four women out of thirty-two total and eight men out of sixty-five published more than ten papers (see table 5.3).

[113] Maria Hornyak, Rigorosenakt, no 4925, AUW.
[114] Hess and Hornyak, "Über die relative," (1920), pp. 661-672
[115] Hess, "Persönliche Erinnerungen," (1950), pp. 43-45. For his discovery of cosmic radiation, Hess received the Nobel Prize in 1936.
[116] Hess, "Persönliche Erinnerungen," (1950), p. 45; Hittner, *Geschichte des Studienfaches Physik,* (1949), p. 217. The US Radium Corporation was the only firm that isolated radium from currently mined ores. The company was founded before the First World War as the first to produce luminous dials on instruments and watches.

Table 5.3 Authors with more than ten publications

Men		**Women**	
Name	**No of public.**	**name**	**No of public.**
Karl Przibram	43	Marietta Blau	15
Hans Pettersson	23	Elisabeth Rona	12
Gerhard Kirsch	15	Elisabeth Kara-Michailova	12
Georg Stetter	14	Berta Karlik	12
Herbert Haberlandt	12		
Stefan Meyer	12		
Gustav Ortner	12		
Franz Urbach	12		

As the above table indicates the most productive core of scientific researchers in the Institute was comprised of just twelve people, one-third of whom were women. Further analysis of the co-authored papers that appeared in the *Mitteilungen* reflects the politics of collaboration in the Institute. Women who belonged to the core research group worked closely together, forming 19% of the total collaborations. Depending on the topic under investigation they alternated research partners and they never abandoned their own research projects, publishing as sole authors at the same time. Additionally, collaborations between men and women covered 29% of the total and were mainly formed within the core research group of the Institute. These percentages map not only the ongoing research projects but, most important, they should be taken as indicators of the positions of men and women in the laboratory. Women led not only their own projects but they also a place at the workbench next to their male colleagues and became part of the team instead of interlopers (see table 5.4).

[117] Hornyak, "Über die Oberflächenionisation," (1921), pp. 135-147; Hess, "Uder den Ionenwind," (1919), pp. 1029-1079; Fonovits, "Über die Erreichung," (1919), pp. 761-793.

Table 5.4 Collaborations at the Institute for Radium Research, 1920-1934

year	Men-men	women-women	men-women
1920			Hess-Hornyak
1922	Przibram-Meyer		Przibram—Kara-Michailova
1923	Kirsch-Pettersson Meyer-Urlich		Przibram-Belar Przibram—Kara-Michailova
1924	Kirsch-Pettersson Ortner-Pettersson		Pettersson—Kara-Michailova
1925	Kirsch-Pettersson Michel-Pettersson		
1926		Blau-Rona	
1927	Kirsch-Pettersson		Rona-Schmidt
1928	Ortner-Stetter	Karlik—Kara-Michailova	Rona-Schmidt
1929	Blank-Urbach Schmidt-Stetter	Blau-Rona Karlik—Kara-Michailova	
1930	Schmidt-Stetter Meyer-Suess Urbach-Schwarz	Rona-Blau	
1931		Blau—Kara -Michailova	
1932	Kirsch-Rieder Kirsch-Graeven Pettersson-Schintlmeister	Blau-Wambacher	Rona-Rieder Deseyve-Kirsch-Rieder
1933	Pettersson-Schintlmeister Kirsch-Trattner Przibram-Haberlant Ottner-Stetter Stetter-Schintlmeister Koehler-Haberlant	Rona-Karlik	Wallner-Merhaut Wambacher-Kirsch Hoffman-Karlik-Przibram
1934	Ortner- Schintlmeister Pettersson- Schintlmeister Haberlandt-Przibram Stetter-Schintlmeister	Rona-Karlik Blau-Wambacher	Haberlandt-Karlik-Przibram Kara-Michailova—Pettersson Karlik-Pettersson

5.6. Politics of Employment and Gender Hierarchies

Although statistics of publications may best reflect the scientific productivity of the Institute's personnel according to gender, they provide a limited picture of what was happening in the Institute. Publications stress women's accomplishments in radioactivity but they say nothing about their academic status, their pay, and the politics of their employment. A survey of the almanac of the Academy as well as the Institute's notebooks of financial revenues and expenses shed light on the gender hierarchy in the professional structure of the Institute. Besides the director's, there were two paid positions assigned to the Institute, namely those of the *ordentliche* and *ausserordentliche Assistent,* or they are usually called, the first and second assistant. Only in 1927 was the Institute able to hire a *wissenschaftliche Hilfskraft* (scientific assistant), a position with lower status than that of the *Assistent.*

During the academic year 1919/20 Victor Hess appeared in the almanac as the first assistant and Hilda Fonovits-Smereker as the second.[118] When Hess accepted the position of *ausserordentliche Professor* at the University of Graz, Karl Przibram succeeded him.[119] Son of Gustav Przibram, a Hungarian Jewish industrialist, Karl belonged to a dynasty. His mother, Baroness Charlotte Schey, came from one of the richest Viennese families. As Przibram described it, "In the house of my parents the prevailing spirit was that of the cultivated Jewish middle-class liberal era, with its unconditional beliefs in progress and its open-mindedness for all the achievements of the arts and sciences."[120] Growing up in such a stimulating environment, Przibram studied physics at the University of Vienna with Exner and Boltzmann and then moved to the University of Graz to work with the physicist Leopold Pfaundler. During the academic year 1902/3, he visited the Cavendish laboratory in Cambridge to work with J. J. Thomson.[121] In 1905 Przibram completed his habilitation at the University of Vienna and worked as *privatdozent*.[122] In 1912, with Meyer's encouragement, he entered the Radium Institute with a research project on coloring

[118] Hess had been the first *Assistent* of the Institute since 1910. The discovery of cosmic radiation in 1912 led to the award of the Liebenpreis of the Austrian Academy of Sciences in 1919 (Hess, "Persönliche Erinnerungen," (1950), p. 43).
[119] Przibram, "1920 bis 1938," (1950), p. 27.
[120] Karlik, "Karl Przibram Nachruf," (1974), p. 380, (translation mine).
[121] Karlik, "Karl Przibram Nachruf," (1974), p. 381.
[122] Kommissionsbericht, December 8, 1915, Przibram's Personalakt, AUW.

and luminescence caused by radioactive rays.[123] After Hess's departure, Przibram was his indisputable successor. In 1922, he was further promoted to an *ausserordentliche Professor* at the University of Vienna with the obligation to teach experimental atomic physics and the agreement to remain as *Assistent* at the Radium Institute.[124]

While Przibram maintained his position until 1938, Hilda Fonovits, now named Fonovits-Smereker, found it difficult to reconcile her motherhood with her scientific career. During the academic year 1920/21, while she had a joint appointment as *Assistentin* to the second Physics Institute, she got married.[125] In 1922, Fonovits quit her job, unable to combine her domestic with her scientific interests. In a letter to Meyer she confessed that "unfortunately until now I have not been successful despite all of my search, to find a reliable employee to substitute me during the day in my child's care and so it is impossible for me to keep my position as an assistant."[126] Fonovits was ready to give up her career in order to meet the standards of motherhood. "I am very sorry," as she admitted, "I have to quit the job I loved, but I have not resulted in any possibility to combine my professional and domestic duties."[127] The double role of a good mother and an active researcher seemed contradictory despite the fact that the city provided a public day care system.

Fonovits-Smereker's successor was Sebastian Geiger, an engineer from Switzerland who maintained the position from December 1, 1922, until his death on May 19, 1924.[128] Soon after, Gustav Ortner took over the position. At the time Ortner was twenty-four years old and a year earlier had just finished his studies in physics at the University of Vienna. Soon after Pettersson arrived at the Institute, Ortner joined his research project and worked as his private assistant from February to June 1924.[129] Along with Max Kindinger, Ortner improved Pettersson's method of preparing strong sources of radium C from radium emanation.[130] In October 1924, with a subsidy from the Austrian Academy of Sciences, he visited the physics institutes in Uppsala and

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[123] Karlik, "Karl Przibram Nachruf," (1974), p. 382.
[124] Molisch to the Bundesministerium für Inneres und Unterricht, July 12, 1922, Przibram's Personalakt, AUW.
[125] Personalstand, Universität Wien, academic year 1920/21, AUW; Bischoff, *Frauen am Wiener Institut,* (2000), p. 67.
[126] Fonovits-Smereker to Meyer, September 9, 1922, AÖAW, (translation mine).
[127] Fonovits-Smereker to Meyer, September 9, 1922. AÖAW.
[128] Sebastian Geiger, Mitarbeiter/ Assistenten, AÖAW.
[129] Gustav Ortner, curriculum vitae, 021, AUW.
[130] Erna Bussecker was among the students who joined the project. She studied the vapour tension of the active products (Hans Pettersson's report to the International Education Board, April 1928, GUA).

Copenhagen to work with Manne Siegbahn and Niels Bohr, respectively, and get trained in röntgenspectroscopy.[131] Most probably with Pettersson's intervention, when in January 1925 Ortner returned to the Radium Institute, Auer Welsbach supported the spectroscopic studies of the team with a generous donation.[132] In the meantime, Ortner met Felizitas Weiss-Tessbach at one of the laboratory workbenches. She was an extended member of Pettersson's research group and, as a doctoral student, Weiss-Tessbach worked on the absorption of gamma rays of radium C.[133] Their marriage took place in 1931. The next year Ortner received his habilitation and Weiss-Tessbach left the Institute.[134] He maintained his position as *Assistent* at the Radium Institute until 1939, when he was promoted as *ausserordentliche Professor* of the University of Vienna.

Although none of the women in the Institute was offered the position of Assistent after Fonovits-Smereker quit it in 1922, some of them did ascend to the position of *wissenschaftliche Hilfskraft*. In 1927 the Austrian ministry of education offered 5000 schillings for the appointment of a scientific assistant at the Radium Institute.[135] Ewald Schmidt was the first to obtain the position as a joint appointment with the second Physics Institute. Attracted by Pettersson's work on artificial disintegration, he entered the Institute during the academic year 1924/25.[136] As Pettersson reported to his sister, "my third assistant, Dr Schmidt, is a jewel." Married on a salary of 125 sek a month, Pettersson was surprised how he could manage.[137] One of Schmidt's first published articles was on the disintegration of aluminum, a central issue in the group's research project.[138] Through his collaboration with Rona he learned the method of preparing strong polonium sources.[139] Later, cooperating with Georg Stetter he gained experience in working with electrical counting

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131 Bericht, Gustav Ortner Personalakt, 029, AUW.
132 Almanach, Akademie der Wissenschaften in Wien, (1926), p. 209, AÖAW.
133 Weiss-Tessbach, "Mikrokalorimetrische," (1928).
134 Bericht, Gustav Ortner Personalakt, 029, AUW. Weiss-Tessbach's name does not appear in the almanac of the Academy after 1931.
135 Stefan Meyer, November 28, 1931, Mitarbeiten/Assistenten, AÖAW.
136 Almanach, Akademie der Wissenschaften in Wien, (1926), p. 216, AÖAW.
137 Pettersson to Mellbye, March 3, 1926, in Agnes to Rentetzi, October 29, 2001.
138 Schmidt, "Über die Zertrümmerung," (1925), pp. 385-404. See also Hans Pettersson's report to the International Education Board, April 1928, GUA; Schmidt, "Über die Zertrümmerung," (1927), pp. 721-740.
139 Rona and Schmidt, "Untersuchungen," (1927), pp. 65-73; Rona and Schmidt, "Eine Methode," (1928), pp. 103-115.

methods.[140] A few months after his appointment at the Radium Institute, Schmidt quit the position in the prospect of becoming an *ausserordentliche Assistent* at the second Physics Institute.[141]

The next to be appointed as research assistant was Elisabeth Kara-Michailova. Born in 1897 to a prosperous bourgeoisie family, she spent her childhood in Vienna and received a private education.[142] Her father, Ivan Kara-Michailoff, was a Bulgarian physician and her mother, Mary Slade, was an English musician. In 1907 her parents decided to move to Sofia where they finally settled down, playing an influential role in the artistic and scientific life of the city.[143] Ten years later Kara-Michailova returned to Austria, this time alone, to enter the University of Vienna. Between 1917 and 1921, Kara-Michailova studied physics, mathematics, chemistry, mineralogy, and philosophy taking eventually a major in physics and minor in mathematics with Meyer and Jäger as the referees of her final exams.[144] Her dissertation was on electrical figures of a variety of materials, particularly crystals.[145] From early on, even before she completed her thesis, Kara-Michailova collaborated closely with Przibram, with whom she published extensively, not only in the *Mitteilungen* but also in the prestigious *Zeitschrift für Physik.* [146] Before she shifted to Pettersson's group in 1923, she focused on the phenomena of photoluminescence and luminescence of radium, Przibram's research program, and conducted photoelectric measurements of the brightness of luminescence in relation to the duration of the radium radiation.[147] It was those experimental skills and her knowledge on fluorescence that Kara-Michailova carried over to the group working on the artificial disintegration of light elements. In November 1928, "with the salary of an *ausserordentliche Assistent,*" Kara-Michailova was offered the position of *wissentschaftliche Hilfskraft*.[148]

[140] Schmidt and Stetter, "Die Anwendung des Rohrenelektrometers," (1929), pp. 271-287; Schmidt and Stetter, "Untersuchungen," (1930), pp. 139-150. See also Hughes, *The Radioactivists,* (1993), p. 153.
[141] November 6, 1928, Mitarbeiten/Asistenten, AÖAW.
[142] KaraMichailova, Rigoresenakt 5215, AUW.
[143] Tsoneva-Mathewson; Rayner-Canham, M., and Rayner-Canham, G., "Elizabeth KaraMichailova," (1997), p. 205.
[144] Kara-Michailova, curriculum vitae, 006, AUW.
[145] Kara-Michailova, Rigorosenakt 5215, AUW.
[146] Kara-Michailova and Przibram, "Orientierte Gleitbüschel," (1920), p. 297; Kara-Michailova and Przibram, "Über Radiolumineszenz," (1922), pp. 511-530.
[147] Kara-Michailova and Przibram, "Über Radiolumineszenz," (1923), pp. 285-298.
[148] November 6, 1928, Mitarbeiten/Assistenten, AÖAW.

Apparently, by the end of March 1933 financial problems prompted Meyer to address the Dean of the Faculty of Philosophy.[149] In the context of the wider European political crisis in March 1933, Engelbert Dollfuss, Austria's chancellor, suspended parliament. The depression and political instability deeply affected the Institute. Kara-Michailova had already decided to apply for a Yarrow Scientific Research Fellowship, a grant that aimed to support women scientists. As she informed Meyer from Sofia, she had the support of her father, who wanted her to continue her scientific research in case she was not able to extend her stay in the Institute after March.[150] Meyer tried to retain the position. On March 21, 1933 he wrote to the Dean, urging to give him the possibility to retain the position even for half of Kara-Michailova's salary. [151] Eventually on April 1, 1933, Karlik was the next to obtain the position. Indeed, her monthly salary was reduced to 150 schillings from 289,5 schillings that Kara-Michailova received in 1932.[152] In 1935 the latter moved to Cambridge and spent four years working at the Cavendish laboratory.[153]

Karlik had entered the Radium Institute as a doctoral student in 1927. She was born in 1904 in an upper class Viennese family. Her father, Carl Karlik, was director of the national mortgage institution for Lower Austria and Burgenland.[154] She lived in a small castle in Mauer, a Viennese suburb, where she always returned for her summer holidays during her adulthood. Adopting the status of her class, she learned to play piano and speak several languages while also taking classes on painting.[155] Although she entered the University of Vienna in 1923, Karlik mainly wanted to take the exams that could enable her to become a teacher and study physics and mathematics on the side. As she later confessed to Reinhard Schlögl, in an interview with the Austrian radio station ÖRF, "I started my studies in 1923. I wanted actually to take the teachers' exam, simple and easy physics mathematics as major, but then

[149] Elisabeth Kara-Michailova, Mitarbeiten/Assistenten, AÖAW.
[150] Kara-Michailova to Meyer, January 18, 1933, AÖAW.
[151] Meyer to Dekan, March 21, 1933, Karlik's file, Mitarbeiten/Assistenten, AÖAW.
[152] January 10, 1934, Karlik's file, Mitarbeiten/Assistenten, AÖAW; December 2, 1932, Kara-Michailova's file, Mitarbeiten/ Assistenten, AÖAW.
[153] Bischof, *Frauen am Wiener Institut,* (2000), p. 95; Tsoneva-Mathewson; Rayner-Canham, M., and Rayner-Canham, G., "Elizabeth KaraMichailova," (1997), p. 206.
[154] Karlik's handwritten note in the box Mittarbeiter/Assistenten, AÖAW.
[155] Bischof, *Frauen am Wiener Institut,* (2000), p. 101.

during my studies my interest for physics became stronger. Then I was especially attracted and did my dissertation in this field."[156]

Even though Karlik could have immediately sought a career in physics by remaining in the Institute, she chose the safe pattern of becoming a teacher. An average monthly salary for Pettersson's collaborators was not more than 200 schillings, an amount that was surely not enough.[157] After taking the teachers' exam, Karlik accepted a position at a *Realgymnasium* in Vienna. Probably more socially engaged than any of her single female colleagues, she was in the circle of some young Austrians with interests in music and democratic politics. In a seminar for female grammar school teachers Karlik became friends with Rosi Jahoda who was studying botany and zoology at the University of Vienna and worked at the *Vivarium*. Franz Urbach, a physicist working at the Radium Institute since 1923, was also part of their group.[158] Karlik retained her cultural and social conducts while sharing her time between teaching and physics research. That was probably the reason that her name did not appear at the Academy's almanac as a collaborator of the Institute until 1932.

Besides Fonovits-Smereker, Kara-Michailva, and Karlik who held paid positions in the Radium Institute, Rona was appointed as an additional *wissenschaftliche Hilfscraft* for only the academic year 1928/29. Erwin Zach, the Austrian-Hungarian general consul in Singapore, and the industrialist Ignaz Kreidl, whose son Norbert was working as a research student in Pettersson's group, funded her position.[159] In the *Institutverrechnung*, a notebook recording monthly financial revenues and expenses one finds that Kara-Michailova, Rona, Blau, and Karlik had paychecks delivered either every month or every two months.[160] A few *Bestätigungen*, littered receipts in the Institute's archive signed by women scientists, confirm that most of them were paid for chemical and photographic tasks they performed as well as for the preparation of radioactive sources. The same holds for many of their male colleagues. As one of the two repositories of radium standards, the Viennese Institute received several requests by hospitals and other institutes to

[156] Bischof, *Frauen am Wiener Institut,* (2000), p. 102.
[157] For example, Kara-Michailova received from July 7, 1926 to June 30, 1927 the amount of 2.400 schillings (200 schillings monthly salary) equivalent to approximately $28 a month at the time (Hans Pettersson's report to the International Education Board and spare notes on his expenses, GUA).
[158] Reiter, "The Year 1938," (1995), p. 198.
[159] Almanach, Akademie der Wissenschaften in Wien, (1929), p. 202, AÖAW.
[160] Institutsverechnung 1922-1932; Kassa 1928-32; Kassa 1933-38, AÖAW.

prepare radium in payment.[161] Thus, most of its research students and personnel, men or women who were engaged in the tedious and dangerous procedure of radium preparations, were reimbursed by the Institute.[162]

Although in Meyer's Institute the gender politics of employment offered women the chance to obtain important research positions that was not the case for the University of Vienna. Out of the women who were affiliated to the Radium Institute, Franziska Seidl was the only one who promoted to the position of *privatdozentin* at the University of Vienna before 1934.[163] In a letter to Meyer on May 3, 1926, Kara-Michailova expressed her distrust about the University's policy on hiring women. "I am absolutely sure that here [in Vienna] they do not let women in and I did it only to satisfy my fathers' wish and to show to the people here [in Sofia] that I am not lazy while I am abroad."[164], Kara-Michailova had applied to the University of Vienna, although it is not clear for which position. Apparently Meyer's encouragement and support was not enough to influence the gender politics of employment of the University. The political turmoil that followed in 1933 threatened not only women's position in academia but their Jewish male colleagues as well.

5.7. Politics Matter: Fortunate Exception or a Piece of Vienna's Political History?

Was the Institute for Radium Research indeed an exceptional case of a physics research center in the 1920s hosting a disproportionate number of women within its walls? As I have shown, women who worked at the Institute were not odd in the laboratory or figures with secondary roles. They were keen researchers, close collaborators with their male colleagues, and experienced experimenters. Some of them published extensively not only in the *Mitteilungen* but also in prestigious scientific journals of their time. A few advanced in the Institute's hierarchy, gaining paid positions as *Assistenten*, or carried their knowledge on radioactivity to other

[161] A survey of the almanac of the academy from 1920 to 1938 reveals that the preparation of radium was one of the main financial sources of the Institute.
[162] A survey of the Institute's notebook of financial revenues and expenses reveals that that was the case for both men and women who performed the task of radium preparations.
[163] Seidl was not a member of the Radium Institute but she worked at the first Physics Institute next door (Seidl Franziska, Rigorosenakt, no. 5602, AUW; see also chapter 4).
[164] Kara-Michailova to Meyer, May 3, 1926, AÖAW.

institutions. Intellectually and socially, women played a crucial role not only within the walls of the building at Boltzmangasse but also in the *Mediziner-Viertel*, working as teachers in the city's gymnasiums or traveling to other institutes, visible as they were in the scientific community. With the men of the Institute they were friends, respected colleagues, close and important collaborators, and as in the case of Weiss-Tessbach, intimate partners. Yet one cannot reconstruct the vivid picture of their everyday life through remnants and dispersed letters. We are left with publications and numbers that give just a glimpse of their stories.

Proposed explanations for the exceptional character of their case, focus on the subject matter of their research. The argument refers to two distinct periods. In its early days, radioactivity was considered a comparatively newly established discipline, which lacked strong male hierarchies. Therefore it was easier for women to integrate in the radioactivity research institutes. In the 1920s, the field was seen as a declining one, with prominent male scientists abandoning it. Only then did women have the chance to enter its institutions in large numbers. The second trend of explanations touches on the character of mentors, directors, and main collaborators. The more supportive they were, the easier it was for women to work in their laboratories. Third, Marie Curie's role as a folk hero and women's model in science completes the standard picture.

Canonical stories of women's roles in science do not take into account that disciplines are not fixed spaces. One can enter or abandon them as if their boundaries remain static and intact, leaving a void that someone else could occupy. A scientific field is a space of constant epistemic and sociological negotiations among its practitioners and over its boundaries. Thus, I argue that women did not "enter" radioactivity research when men "abandoned" it. On the intersecting boundaries among different disciplines women, among others, played an important role in redefining what radioactivity was and by whom it was practiced. Working in hospitals, centers for radium therapy, and radium laboratories throughout the 1920s and early 1930s, women transferred their knowledge from physics and chemistry to medicine, renegotiating the boundaries of their discipline.

Moreover, one cannot really assess the psychological effect of Curie's role as a model for women in science. No evidence suggests that the entrance of especially the first generation of women in radioactivity research, such as Blau and Rona, was affected by Curie as a leading figure in the field. Taking also into account the scandal that surrounded Curie's affair with Paul Langevin in 1911 and the unfavorable way that the press treated her, it is doubtful that any women would have wished to be in her position. At stake was not only Curie's personal life but more important her career as a woman in science.[165]

Finally, the role of Stefan Meyer as director of the Institute and the presence of supportive figures such as Przibram and Pettersson were indeed instrumental factors for welcoming women in the Institute. Is the presence of a kind personality enough to explain a social phenomenon that took place during the 1920s in Vienna, though? As I have stressed throughout this chapter, besides the indisputable fact that Meyer's personality was crucial for women to forge careers in the Institute and elsewhere, he was also politically inclined to support women's active participation in science. As in the case of the *Vivarium,* the Radium Institute hosted a number of liberal, socialist, and Jewish scientists as well as a remarkable number of women. While the University of Vienna kept its doors tenaciously closed to women as professors and only a few slipped into the positions of *privatdozent* and *dozent*, private institutes or those supported by the municipality were open to women. The case of the Austrian Academy of Science is more indicative. The first woman to become a member was Lise Meitner in 1948.[166]

Was then the Radium Institute a fortunate exception for women who wished to pursue careers in radioactivity research? In this chapter I argued that indeed it was an exception but not simply a lucky exception. On the contrary, it was part of the political history of Vienna. With the Social Democrats having control of the city, women became a political category. The party's discourse and its projects of social reform created the conditions for women to envision themselves as socially active. In Red Vienna women entered the University as students in remarkable numbers and sought careers in welcoming institutes such as Meyer's. The limits of the socialist project became apparent when women challenged the university politics of employment. Thus, the point of examining the history of the Institute as part of the political history of the city is twofold. On the one hand, references to the political context of Red Vienna underline associations that the terms gender and politics

[165] For Curie's affair with Langevin see Pycior, "Marie Curie," (1997), pp. 31-50.
[166] Vogt, "Women Members," (2000), p. 1.

carried in the specific cultural and scientific location of the Radium Institute. The social process of attributing meaning to sexual difference and the construction of power relations was determined by the political context within which it took place. On the other hand, the same references to politics provide the conceptual framework, instead of causal explanations, for understanding why women chose to join an institute devoted to radioactivity research in the specific geographic location of Vienna. Thus, from the universal categories of men and women one shifts to the local understanding of what it meant to be a man and a woman in physics in early 20th century Vienna.

CHAPTER 6:
LABORATORY TECHNOLOGIES AND GENDER:
THE SCINTILLATION COUNTER

Despite the vast literature on technology and gender, most of the recent studies are focused on biomedical and information technologies.[1] When the physics laboratory is addressed, the point is to demonstrate that women are often used as calculators, scanners, unskilled assistants, and cheap labor force in science.[2] However, historically this has not been the case in every laboratory setting. Indeed, the Institute for Radium Research was one of those exceptional places where women physicists built a unique relation to the technologies of their discipline. From all laboratory technologies I focus on the scintillation counter, as it was an essential part of the research program on artificial disintegration set up by Pettersson and his colleagues in Vienna. The active role of women in the group reveals implicit assumptions about gender roles within the Institute and explicit gender politics of collaboration.

The reason I chose the scintillation counter as the focus of study is twofold. First and foremost, the counter embodied the hopes of Ernest Rutherford to support his atomic model. In both his laboratories, first in Manchester for his alpha scattering experiments and then in Cambridge for his artificial disintegration experiments, Rutherford and his group relied heavily on the counter as the principal instrument for conducting their research. Second, the transformation of the instrument in the Cambridge laboratory to the Viennese Institute in late 1922 involved changes in the gender assumptions that accompanied its use.

In what follows I consider the scintillation counter as a historical document that reflects a number of social and epistemic meanings embodied in its construction

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[1] See for example, Berg and Mol, *Differences in Medicine,* (1998); Clarke and Fujimura, *The Right Tools for the Job,* (1992); Rapp, *Testing Women, Testing the Fetus,* (1999). For a review of the technology and gender issue see Faulkner "The Technology Question in Feminism," (2001), pp. 79-95; Grint and Gill (eds), *The Gender-Technology Relation,* (1995); *Technology and Culture,* (1997); Wajcman, "Reflections on Gender and Technology Studies," (2000), pp. 447-464.

[2] For example, as Rossiter argued in 1980, the rise of big science and the flow of significant budgets at the end of the 19th century, enabled women to enter scientific fields as support staff or assistants at a few research centers. The most illustrative example is the entry of women in astronomy with the main task to classify photographs of stellar spectra. (Rossiter, "Women's Work in Science," (1980), pp. 287-304.) Caroline Herzenberg's and Ruth Howes' book *Their Day in the Sun: Women of the Manhattan Project* pieces together fascinating information on women in the atomic bomb. Throughout the study it becomes apparent that those who took key decisions and shaped laboratory technologies were not the women but the men who worked at the project (Herzenberg and Howes, *Their Day in the Sun,* (1999)).

and use.[3] As the major link tying together a small group of physicists at the Radium Institute, the scintillation counter enabled them to bring their laboratory to the cutting-edge of radioactivity research. The scientific knowledge required for its use further sustained the work of a number of women in the Institute and brought together scientists from different research teams. Demonstrating technical dexterity, women physicists manipulated the instrument, playing the role of instrument makers together with their male colleagues.

As Julian Holland argues, scientific instrument makers have not been studied in their institutional context.[4] The rise of practical scientific research in the 19th and early 20th century led to an increasing demand for specialized scientific instruments. Special contractual arrangements with local makers, the direct employment of skilled technicians on the staff of the scientific institutions, and the commercial supply from instrument making, companies satisfied those needs. In the case of the Viennese Institute, scientists themselves were engaged in instrument making using tabletop and flexible structures. For improving the scintillation counter, Pettersson and Kara-Michailova approached the Carl Reichert Company, a local maker of optical instruments, asking for a special microscope. The remaining parts of the instrument were easily constructed and prepared by the Institute's personnel. Women such as Karlik, Maria Belar, and Rona prepared the scintillation screens, worked on the radioactive sources, and measured the absorption of glasses and foils essential to their own experiments. To focus on laboratory technologies utilized by the women of the Institute and especially that of the scintillation counter, it means to pay attention on how experiments were performed and how women formed their identities as experimenters, actively engaging with the whole set of the experiments' aspects.

6.1. Hans Pettersson

Hans was the son of Otto Pettersson, the founder of oceanography in Sweden and professor of chemistry at the Stockholm Högskola. According to those who knew Hans well, it was his father's strong personality that prompted him to shape his career

[3] For considering instruments as historical documents see Bedini, "The Hardware of History," (2001), pp. 540-544.
[4] Julian Holland, "Scientific Instrument Makers in an Institutional Context" talk given at the XXI International Scientific Instrument Symposium, National Hellenic Research Foundation 2002, Athens, Greece.

far away from Sweden and in a different field than oceanography.[5] Otto Pettersson was a gifted administrator and organizer, president of a number of national and international oceanographic committees, and highly influential in academic politics. In 1902 he established the first oceanographic station in Sweden at Bornö, in the Gullmar Fjord.[6] As a child, Hans spent long summer holidays at his father's estate at Holma on the Gullmar Fjord, sailing and rowing, fishing and hunting. Agnes Rodhe, Pettersson's daughter explained that, "each summer people belonging to his mother's family of Norwegian civil servants, writers and painters, used to visit Holma, tempering its rough-and-ready atmosphere with their gentler, old world culture."[7] When in 1908 Otto moved his family permanently to Bornö after their house in Stockholm burned down, Hans was already twenty years old and at Uppsala University, where he went to study physics under Knut Angström.[8]

Soon after, Pettersson expressed his interest in radioactivity research. Prompted by Angström, the year he completed his studies he published a paper on the heating effect of radium.[9] From October 1911 to August 1912 he worked at the University College in London under William Ramsay, a close friend of his father.[10] It was the dominant Otto who had arranged his son's early involvement in radioactivity research in Ramsay's laboratory, giving him "a year of freedom to get around the world."[11] Arriving in London, Pettersson had little idea of what he was supposed to work on and soon Ramsay offered him as dissertation topic the construction of a microbalance.[12] In this early work Pettersson addressed the problem of accurate physical measurements and aimed to construct a balance with sensitivity of more than 1/250000mg.[13] Working with Ramsay, Pettersson acquired skills invaluable for his

[5] Most of the biographical information on Pettersson comes from an interview with his daughter Agnes Rodhe on September 22, 2001, Göteborg and with Arthur Svansson, an oceanographer and biographer of Otto Pettersson, on September 21, 2001, Göteborg. For the early period in Ramsay's laboratory see Rodhe, Vikarvets Arsbok, 1998-1999, pp. 18-47.
[6] Svansson, interview by the author, September 21, 2001, Göteborg.
[7] Rodhe to Rentetzi, October 29, 2001.
[8] Svansson, interview by the author, September 21, 2001, Göteborg.
[9] Peterrson, "Contribution à la connaissance" (1910), pp. 1-9. See also Hans Pettersson's report to the International Education Board, April 1928, GUA.
[10] Karlik, "Hans Pettersson Nachruf," p. 305.
[11] Rodhe to Rentetzi, October 29, 2001.
[12] Pettersson, *A New Microbalance and its Use*, (1914).
[13] The same problem had occupied both his advisor Angström, who had made a balance as early as 1895, and Ramsay, who measured the density of a tiny amount of radium emanation, using a balance made by his students Steel and Grant. For example, Ramsay and Whytlaw-Gray determined the atomic weight of radium on a minute quantity of pure $RaBr_2$, verifying earlier measurements done at the Curies' laboratory (Pettersson, *A New Microbalance and its Use*, 1914). It is worth noticing that the quantities of radium, which Ramsay had been working on, came also from the Bohemian mines. As I

later experimental research in physics. According to Rodhe, although he never trained in mathematics, something that probably hampered his later career, he was “a devil at building apparatus.”[14] It is not by chance that in the following years after his return to Sweden in 1911, Pettersson showed a great interest in constructing instruments useful in oceanography.[15] In 1913 he was appointed to the staff of Svenska Hydrografiska Biologiska Kommissionen. A year later he defended his dissertation and obtained a lectureship at Göteborg Högskola, torn between radioactivity and hydrography, something that Rodhe explained as a struggle between his father’s wishes and his own interests.[16] His position as a lecturer offered him a negligible salary that only his work as an assistant hydrographer at the Bornö Station could supplement.

In the summer of 1921 Pettersson approached Rutherford, suggesting some experiments with radium and the use of his sensitive balance. Rutherford’s response might not have been very encouraging for the young Pettersson. “I am not sure from your letter whether you have the use of 200mg of radium for several years for your experiments.” Instead of a direct invitation, Rutherford continued, “I am sorry that I will not be in Edinburgh this year, but will be in Cambridge in the 4th week of September.”[17] In his response, Pettersson mentioned Stefan Meyer’s offer from years ago to use the radium at the Institute in Vienna. “I am unfortunately not able to get any large quantity of radium in this country,” as Pettersson informed him, wondering “whether Meyer is able to keep his offer open under the present state of things.”[18] Rutherford did not seem willing to issue a warm invitation, and in his last response claimed that the laboratory will be closed for the first three weeks of September. “I am afraid that this will make it rather difficult to see you unless you are able to stay in England over some time.”[19] Even Pettersson’s strategic mention of his father did not

have already mentioned in the second chapter, in 1907 Ramsay received a loan of 300mg $RaBr_2$ from the Austrian Academy of Sciences with the commitment to share it with Rutherford. Soon after, the arrangement brought tension between the two British laboratories. That could explain the reasons for which Pettersson later on turned to Vienna for his radioactivity research instead of Rutherford’s laboratory in Cambridge.

[14] Rodhe to Rentetzi, October 29, 2001.

[15] Pettersson, “Some New Instruments in Oceanographical Research,” (1917), pp. 159-164; Pettersson and Angström, “Ein neues Totalimmersions-Aräometer,” (1917), pp. 177-180; Pettersson, “Zur Technik der Dichtigkeitsbestimmung,” (1917), pp. 19-25 and 87-93.

[16] Rodhe, interview by the author, September 22, 2001, Göteborg.

[17] Rutherford to Pettersson, June 24, 1921, GUA.

[18] Pettersson to Rutherford, July 4, 1921, GUA.

[19] Rutherford to Pettersson, July 12, 1921, GUA.

help. "My father, late chairman of the Nobel committee for chemistry, sends you his best remembrances."[20]

Probably due to the unsuccessful course of his correspondence with Rutherford, Pettersson accepted instead an invitation from Prince Albert I of Monaco to work on the radium concentration of the deep sea sediments from the Challenger expedition. The Musèe Oceanographique, the institute in Monaco, nonetheless, was lacking substantial apparatuses. At the end of 1921, considering the low cost of life in post-war Vienna and the remarkable instrumentation existing in the Viennese Institute, Pettersson turned to his old contact Stefan Meyer.[21] His request was very modest. Besides the measurements of radioactivity in sea sediments, he wished to work on disintegration of radioactive elements in case there was a small amount of $RaBr_2$ available. Meyer had been several times hospitable to foreign scientists, and in Pettersson's case, there was one more reason to accept his request. In a postscript Pettersson added, "I bring with me a sensitive thread electrometer with a voltammeter and my institute in Göteborg Högskola, Sweden, provides me with the necessary resources for my work."[22] Since the Institute had a hard time supporting its own scientists it would be impossible to provide Pettersson with more than work space. After Meyer's positive response, Pettersson promised to be in Vienna in the beginning of January 1922, but he did arrive until March of that year.[23] During the summer of 1922 Hans and his wife, Dagmar Pettersson, returned to Sweden impressed by the friendly and stimulating atmosphere in the Institute.[24] On their return in the coming fall, Pettersson threw himself in intense work on artificial disintegration, establishing a strong research team, and enlisting a number of patrons to support it.

For the next three years, Pettersson divided his time between radioactivity research in Vienna and his lectures in Göteborg, feverishly searching for financial support. Amazingly energetic and ingenious, Pettersson approached Albert Einstein, securing his prestigious recommendation to the Swedish patrons. The connection seems to have been made through Otto Pettersson, thanks to his high status in the

[20] Pettersson to Rutherford, July 17, 1921, GUA.
[21] Rodhe to Rentetzi, October 29, 2001. Pettersson had already contacted Meyer in 1914 from Bornö, asking his permission to perform some of his measurements in Vienna. (Petersson to Meyer, April 26, 1914, OAW; Pettersson to Meyer, May 24, 1914, AÖAW).
[22] Pettersson to Meyer, November 28, 1921, AÖAW, (translation mine).
[23] Pettersson to Meyer, December 14, 1921, AÖAW.
[24] Pettersson to Meyer, June 4, 1922, AÖAW.

Swedish scientific community.[25] During Göteborg's jubilee exhibition in 1923, Einstein lectured to a large audience. As Hans wrote to him afterwards, "Unfortunately I had no opportunity to thank you during the Naturforschertag in Göteborg for your very friendly recommendation for the upcoming research on the atomic disintegration that I worked on with Dr. Kirsch and Dr. Geiger."[26] A long list of the needed instruments for his experiments followed his gracious opening and a detailed work program closed the letter nicely. Apparently, Pettersson had inherited father's gift for raising funds: between 1923 and 1925 he secured the amount of 7000 dollars from Swedish institutions, several societies, and patrons.[27] At the time, "the total grant of the Radium Institute in material and equipment was equivalent to a sum of about 110 dollars per year, which was totally inadequate and prohibited all attempts to investigate problems for which new instruments had to be bought or constructed."[28] Taking into account that by the mid-1920s, the Austrian economy was stabilized by the flow of foreign loans, the Institute was finally in the position to support its personnel.

6.2. Entering the World of Artificial Disintegration

Bringing money and instruments into an institute that is barely supporting its personnel might be a necessary but surely not a sufficient condition for boosting it to the forefront of scientific research. The skills and the ingenuity of the experimenters are those elements that give life to the material culture of the discipline and often rework its theories. Hans Pettersson had both. He was keen in designing experiments. Yet, he was also impulsive enough to have "big ideas"[29] and persistent enough to

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[25] From 1910 to 1922 there had been a long debate on whether Einstein should be awarded the Nobel Prize or not. The Nobel committee, as Carl-Olov Stawström argues, was dominated by representatives of the Uppsala's strong empirical tradition (Stawström, "Relative Acceptance," (1993), p. 299). Given his prestigious status within the University of Uppsala and the international community, Otto Pettersson must have known Einstein from that time.

[26] Pettersson to Einstein, August 18, 1923, AEA, (translation mine).

[27] For example, from 1923 to 1925 Pettersson received funds from the following Swedish sources: Längmanska Fonden, Lars Hiertas Minne, and the Göteborg Högskolas Oceanografiska Institution (Hans Pettersson's Finances, International Education Board, GUA).

[28] Hans Pettersson's report to the International Education Board, April 1928, p. 2, GUA.

[29] In his interview, Arthur Svansson stressed several times Pettersson's strong personality and his impulse for "big ideas, wild ideas." As Svansson claimed, "His was not afraid to have theories that were not easy to be proved" (Svansson, interview by the author, September 21, 2001, Göteborg).

pursue them. In a field that only “the Devil knows what can happen anytime,” Pettersson was not afraid to play along.[30]

At the time the most promising set of problems in radioactivity research was related to artificial disintegration. In 1919, still in Manchester, Rutherford noticed an anomalous effect in the collision of alpha particles with nitrogen. When pure nitrogen was bombarded by fast radium C alpha particles, long-range atoms arose from the collision that were probably “atoms of hydrogen or atoms of mass 2. If this be the case,” as Rutherford argued, “we must conclude that the nitrogen atom is disintegrated under the intense forces developed in a close collision with a swift alpha particle, and that the hydrogen atom which is liberated formed a constituent part of the nitrogen nucleus.”[31] When in the fall of 1919 Rutherford took over the directorship of the Cavendish Laboratory in Cambridge, he pursued his earlier studies on artificial disintegration with great zeal. As Jeff Hughes has documented, by introducing this new research program Rutherford reorganized the Cavendish laboratory as a whole.[32] An inflow of research students, changes in the material culture, and spatial rearrangement of the laboratory marked his arrival in Cambridge. By the end of March 1920, Rutherford had concluded that the particles from nitrogen were actually hydrogen nuclei, as he had first speculated.[33]

James Chadwick, Rutherford’s research student in Manchester, joined him in Cambridge as well, serving as a reliable and experienced experimenter. In the course of 1921, besides nitrogen, both tested a series of light elements for the disintegration phenomenon. As they concluded, only those whose atomic mass was given by $4n + 2$ or $4n + 3$, where n was a whole number, expelled long-range disintegration particles. Seventeen other elements, including carbon and oxygen, yielded no detectable disintegration protons. In August 1921, and drawing on those experimental results, Rutherford and Chadwick argued that the atomic nucleus consisted of a central core of alpha particles surrounded by protons as distant satellites.[34] Thus the artificial disintegration experiments had a theoretical bearing that made them attractive to any ambitious researcher. Pettersson was very much one of those.

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[30] Pettersson to his sister E. Mellbye, March 7, 1926, (in Swedish, Agnes Rodhe Papers, translated by Rodhe).
[31] Rutherford, “Collisions of alpha-particles with Light Atoms,” (1919), p. 589.
[32] Hughes, *The Radioactivists*, (1993).
[33] Hughes, *The Radioactivists,* (1993), p. 20.
[34] Rutherford and Chadwick, “The Artificial Disintegration of Light Elements,” (1921), p. 61.

Shortly after his first visit to Vienna in 1922, Pettersson established a close collaboration with Gerhard Kirsch and worked on artificial disintegration. Their first paper came out in 1923. A full version was published in the *Sitzungsberichte* of the Vienna Academy and in the *Philosophical Magazine,* while a short report appeared also in *Nature*.[35] The multiple publications implied the importance of their results, which differed significantly from those obtained in Cambridge. "Our results," as they both argued, "seem so far to indicate that the hydrogen nucleus is a more common constituent of the lighter atoms than one has hitherto been inclined to believe."[36] Elements such as beryllium, magnesium, and silicon were disintegratable, despite the fact that Rutherford and Chadwcik had stated otherwise. As Roger Stuewer has documented in detail, with that paper Pettersson and Kirsch generated a milestone in the history of physics controversy with Rutherford's research group. Between 1923 and 1924 the debate got heated, with the two groups zealously publishing their conflicting experimental results in the most internationally prestigious journals. At stake was not only the authority of the Cavendish laboratory in the world of radioactivity and Rutherford's theoretical satellite model. The material culture of the Cambridge group—its experimental methods, the instruments and the politics of collaboration they embodied—were under a vigorous attack. The focus was mainly the scintillation counter.

6.3. The Early Days of the Scintillation Counter

What for Friedrich Giesel was the best way to detect the easily absorbed alpha radiation of polonium, to William Crookes became best in exhibiting the luminosity of radium in a screen. Zinc sulfide served both purposes. We have already encountered Giesel when he handed the first amount of radium to Meyer back in 1899. Crookes was an exceptionally gifted chemist interested in "those areas where chemistry meets physics."[37] When he approached Giesel and asked him to recommend a medium for exhibiting radium on a screen, Giesel suggested zinc

[35] Kirsch and Pettersson, "Über die Atomzentrümmerung," (1923), pp. 299-307; Kirsch and Pettersson, "Experiments on the Artificial Disintegration," (1923), pp. 500-512; Kirsch and Pettersson, "Long-range Particles," (1923), 394-395.
[36] Kirsch and Pettersson, "Long-range particles," (1923), p. 395.
[37] Gay, "Invisible Resource," (1996), p. 314.

sulfide.[38] Eventually, in 1903, Crookes was the first to describe the evanescent flashes appearing on the suggested screen when he brought radium close to it.[39] Performing several experiments in order to test different factors influencing the number of scintillations, Crookes constructed a very simple apparatus. No schematic representation accompanied the text and only a short description was given. As Crookes described it, "A blend screen was fixed near a flat glass window in a vacuum tube, and a piece of radium salt was attached to an iron rocker, so that the movement of an outside magnet could bring the radium close to the screen or draw it away altogether. A microscope gave a good image of the surface of the screen, and in a dark room the scintillations were well seen."[40] The first scintillation counter was already constructed and Crookes proposed to call the instrument "spinthariscope" from the Greek word spintharis—a scintillation.[41] What Crookes thought of actually observing was the impact of electrons on the screen. Shortly after, Julius Elster and Hans Geitel confirmed Crookes' observations.[42] In 1908 Erich Regener used the method to record alpha particles of polonium.[43]

In its generic form, in the early 1920s the scintillation counter was a very simple instrument. It consisted of a screen, a thin glass plate spread with an equally thin layer of zinc sulfide. When it was struck by charged particles, the screen produced light flashes. The scintillations were observed through a microscope, which was specifically designed to increase the brightness of the flashes. By manipulating the microscope and its light-gathering power, the experimenter could work with weak radioactive sources and still observe a fair number of particles. The observations done in a dark room were tiring and tiresome and the counting fragile, heavily dependent on the experience of the observer.

It was on this phenomenologically simple apparatus that Rutherford relied for his early work on the properties of alpha particles. In his Nobel lecture in 1908 Rutherford compared the scintillation technique to the electrical method for counting alpha particles that he and Geiger had constructed the same year. The scintillation counter was found to be reliable. He further proved that each alpha particle produced

[38] Kirby, "The Discovery of Actinium," (1971), p. 300.
[39] Crookes, "The Emanation of Radium," (1903), pp. 405-408.
[40] Crookes, "The Emanation of Radium," (1903), p. 407.
[41] Levy and Willis, *Radium and Other Radio-Active Elements,* (1904), p. 50.
[42] Elster and Geitel, "Über die durch radioactive Emanation," (1903), pp. 439-440.
[43] Regener, "Über die Zählung der a-Teilchen," (1908), p. 78-83.

a single visible scintillation on the screen.[44] Ten years later, manipulating the counter for his collision experiments, Rutherford argued that, "under good conditions, counting experiments are quite reliable from day to day."[45] Taking personal charge of the counting, he added that, "those [countings] obtained by my assistant Mr. W. Kay and myself were always in excellent accord under the most varied conditions."[46] In his Bakerian lecture a year later, where Rutherford laid out his satellite model of the nucleus, it was apparent that he relied on the use of the scintillation method for his artificial disintegration experiments.[47] Placing great value on the technique and especially on the scintillation observers, Rutherford never forgot to acknowledge them in his papers. For William Kay, he granted an important role to the discovery of artificial disintegration by thanking him "for his invaluable assistance in counting scintillations."[48]

Overall, for Rutherford's group the scintillation counter meant maintaining a research tradition. While Rutherford was still in Manchester, his assistants Walter Makower and Hans Geiger set up a course in training research students in the experimental techniques used in radioactivity. The scintillation method was by far the most important.[49] It was Chadwick who took up the course when he followed Rutherford to Cambridge. "Under Chadwick's careful surveillance,"[50] Rutherford enlisted his students, to whom he eventually assigned specific research projects after a short training in scintillation counting.

However, the detection of alpha particles in the zinc sulfide screens by the visual observation of the individual scintillations was neither easy nor always reliable. The evidence was fragile, depending on the radioactive contamination of the counting apparatus and the presence of hydrogen impurities. Besides alpha particles, the source often produced beta and gamma radiation that interfered with counting, increasing the number of flashes. Additionally, weak scintillations were not always observable. The observer ought to have control not only of the counter but of his optical system as

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[44] Rutherford, "The Chemical Nature of the alpha-Particles," (1908), p. 143.
[45] Rutherford, "Collision of alpha particles with Light Atoms," (1919), p. 551.
[46] Rutherford, "Collision of alpha particles with Light Atoms," (1919), p. 551.
[47] Rutherford, "Nuclear Constitution of Atoms," (1920), p. 14-38.
[48] Stuewer, "Artificial Disintegration," (1985), p. 240; See also Hughes, *The Radioactivists*, (1993), p. 62. For issues of authorship in the discovery process see Galison, *Image and Logic,* (1997), pp. 199-200.
[49] Makower and Geiger, *Practical Measurements in Radioactivity,* (1912). For details on the course see Hughes, *The Radioactivists,* (1993), pp. 42-46.
[50] Hughes, *The Radioactivists*, (1993), p. 45.

well. Rutherford, Chadwick, and Ellis affirmed that, "The superior efficiency of an experienced observer appears to be due to greater concentration, to control spontaneous movements of the eye, and to practice in using external portions of the retina, thereby avoiding the insensitive fovea-centralis."[51] The issue of control stood at the center of Rutherford's research project in a dual sense. Control of the observers of the scintillations meant constant crosschecks of their countings and manipulation of their apparatus. To Rutherford, control had a further bearing on his whole laboratory life. Essential to his theoretical atomic model, the scintillation counter was the means by which Rutherford hoped to detect the atomic structure.

With Rutherford's research program depending entirely on the scintillation counter, the modification of the technique became urgent. The first step was to change the optical system by utilizing a new microscope that increased the brightness of weak scintillations. "We have found most suitable for our purpose a holoscopic objective of focal length 16mm and aperture 0.45."[52] The final magnification of the system was about 40. To protect the observer from the gamma rays of the source they used suitable absorbing screens and a reflecting prism. Next they improved the scintillation screen by employing a thinner and finely powdered layer of zinc sulfide, aiming to reduce the luminosity due to gamma rays. In addition, a strong magnetic field deflected the beta rays. It was at that point that the scintillation counter developed from a clumsy technology to Rutherford's powerful vehicle for restructuring not only the material culture of his laboratory but physics in the Cavendish as well.[53] In the hands of the Cambridge experimenters, the scintillation counter was transformed to a promising technique for maintaining the laboratory's authority in the postwar world of radioactivity.

The above changes in the material structure of the instrument simultaneously posed constraints that altered the politics of collaboration in the performance of experiments. To protect against visual mistakes and exhaustion, men alternated in counting scintillations for one minute each. As Rutherford's acknowledgments show, the practice of scintillation counting in Cambridge was a male preserve and this

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[51] Rutherford, Chadwick, and Ellis, *Radiations from Radioactive Substances,* (1930), p. 550.
[52] Rutherford and Chadwick, "The Artificial Disintegration of Light Elements," (1921), p. 49.
[53] For a general history of the Cavendish Laboratory and different research styles see Goldhaber, "Reminiscence," (1993), pp. 1-25; Growther, *The Cavendish Laboratory*, (1974); Larsen, *The Cavendish Laboratory,* (1964); Sviedrys, "The Rise of the Physical Sciences," (1970), pp. 127-52; Falconer, "J.J. Thomson and the 'Cavendish' Physics," (1989), pp. 104-117. For physics in Cambridge

included the task of recording data, making the necessary adjustments to the instrument, and most importantly observing evanescent scintillations.[54] Likewise, in Rutherford's group, the tasks of instrument-making and experimenting were also gendered. From the published historical studies on Rutherford's team it appears that there were no women researchers participating in the artificial disintegration experiments.[55] Apparently, in the Cavendish laboratory experiments with the scintillation counter and the observation of flashes were male projects. Thus, by the time that Pettersson and Kirsch started their research in Vienna in 1922, the scintillation counter was already more than an instrument in the experimenters' hands. It embodied specific politics of collaboration and illustrated gender assumptions about skill in observing and manipulating the apparatus.

6.4. Technology Transfer: The Scintillation Counter in Vienna

When in late 1922 Pettersson and Kirsch performed their first artificial disintegration experiments at the Radium Institute in Vienna, they used the scintillation method exclusively. If they were to undermine Rutherford's and Chadwick's experimental results concerning the artificial disintegration of light elements, there was no alternative to the scintillation technique.[56] However, as Galison has illustrated, "objects travel clothed in culture and human interactions. Objects are encumbered, covered with meanings, symbolisms, power and the ability to represent but also to preserve specific elements of continuity. Yet precisely because things come dressed with meaning, it is essential not to picture the handing down as occurring without alternation."[57] Through its transfer from Cambridge to Vienna the scintillation counter was transformed into a different instrument, 'clothed' now in the

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from a gender perspective see Gould, "Women and the Culture of University Physics," (1997), pp. 127-49.

[54] For Rutherfords' attitude towards women see Rayner-Canham, M. and Rayner-Canham, G. *A Devotion to their Science,* (1997), pp. 20-22.

[55] Although in Manchester Rutherford had a number of women research students, in Cambridge there has been none. This claim is based mainly on Rayner-Canham, M. and Rayner-Canham, G. *A Devotion to their Science,* (1997); Hughes, *The Radioactivists,* (1993). Also there were no women research students mentioned in the original papers of Rutherford and Chadwick. Some of the male students that Rutherford acknowledged for counting scintillations were Ellis, Blackett, Barton, Hirst, and Osgood.

[56] Although important, scintillation counting was not the only method that Pettersson and Kirsch were planning to use. As they announced in their first paper, the emanation capillaries enclosing the sources used in the scintillation counter "will be used in this Institute also for studying atomic disintegration by the Wilson method." Kirsch and Pettersson, "Long-range Particles," (1923), p. 395.

Viennese culture of radioactivity. It is those transformations I want to trace here, focusing especially on the alteration of the gender assumptions that the apparatus carried over to the Radium Institute.

As a gifted instrument maker, Pettersson's first step was to improve the preparation of the radioactive source employed in the experiments. He developed a new method for the preparation of radium C that gave alpha particles of high intensity.[58] The method consisted in enclosing dry radium emanation mixed with pure oxygen in thin walled capillary tubes made out of quartz.[59] Later with the help of Kirsch, Pettersson constructed a different emanation vessel "in which the substances to be examined are spread in thin layers over copper."[60] According to their results, silicon, beryllium, magnesium, and lithium yielded protons of ranges 18cm, 12cm, 13cm, and 10cm in air, respectively. Apparently, contradicting Rutherford's and Chadwick's research, those elements proved to be disintegradable.

In late autumn of 1922, two of Rutherford's students, L. Bates and J. Rogers, were assigned to study long-range alpha particles from radium C. When Pettersson and Kirsch published their first paper, Bates and Rogers already had a response in hand. On September 22, 1923, they reported in *Nature* that radium C emits not only the usual range alpha particles of 7 cm but also ones of longer ranges.[61] Thus, as they argued, it could have been possible that what Pettersson and Kirsch thought they were observing were actually long-range alpha particles instead of disintegration protons. In their reply, Pettersson and Kirsch stressed the fact that the ratio in luminosity between alpha and H-particles (protons) does not permit such a mistake as Bates and Rogers attributed to them.[62] On July 19, even before the articles were published,

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57 Galison, *Image and Logic,* (1997), p. 435.

58 Pettersson, "Zur Herstellung von Radium C," (1923), pp. 55-57.

59 The decision to replace the metal tubes with pure fused silica (quartz) was probably based on Stefania Maracineanu's recommendation that glass instead of metal plates should be used in order to obtain good results for the periods of radioactive substances (Maracineanu, "Researches on the Constant of Polonium," (1923), pp. 1879-1923). For more on Maracineanu and her work at the Curie's laboratory see Popescu, Rayner-Canham, M., and Rayner-Canham, G. " Stefanie Maracineanu," (1997), pp. 87-91.

60 Kirsch and Pettersson, "Long-range Particles," (1923), p. 395.

61 For a long time it was considered that alpha particles, emitted by a given substance, have a definite range. By studying the emitted radiation of thorium in 1906, Otto Hahn discovered that alpha rays can have different ranges for the same source. In 1919 Rutherford established the presence of particles of range 9.0cm from radium active deposit (Bates and Rogers, (1924) "Particles of Long Range," p. 97-98). With their experiments Bates and Rogers observed even longer ranges emitted from radium C such as 9.3cm, 11.1 cm and 13.2cm. (Bates and Rogers, "Long-Range alpha-Particles," (1923), pp. 435-436).

62 Kirsch and Pettersson, "Long-Range Particles," (1923), p. 687.

Rutherford sent his results to Pettersson.[63] In a friendly and grateful response on July 27, Pettersson tried to reconcile and explain the discrepancies. The line of his defense was centered on the scintillation method that he and Kirsch had already modified.

> I lately had the counting box modified so as to allow the source as well as the substance of being enclosed while the pressure is varied. Preliminary experiments seem to show that with this arrangement contamination can be avoided also at low pressures, so that the particles from carbon and other elements may be investigated down to the very shortest ranges. [64]

The modification of the counting box, nonetheless, was not the only innovation that the Viennese experimenters added to the scintillation counter. As Pettersson continued,

> our newest microscope with the scintillation screen directly attached to the front lens by means of cedar oil (a Watson Holoscopic of n.a. 0.70 and f=12) is so superior with regard to brilliancy of the scintillations viewed through it, that we feel much more confident than with the microscope previously used not only in differentiating between scintillations from alpha and from H-particles but also in counting the latter also relatively near the end of their range. For this reason alone I regard any confusion between H-particles and contamination alpha-particles as improbable.[65]

In their next publication, submitted to the *Proceedings of the Royal Society* on December 5, 1923, Bates and Rogers seemed doubtful. Without any direct reference to Pettersson and Kirsch, they suggested that the observed long-range particles were alpha particles from the contamination of the source. However, as they admitted, “this evidence is far from conclusive, as these particles have never been observed alone but always when accompanied by particles of different types.”[66] Faithful to the material culture of their laboratory, they used the same microscope, with a holoscopic objective of numerical aperture 0.45 and 16 mm focal length that was previously utilized by Rutherford and Chadwick. Specially constructed, the eyepiece consisted of two large plano-convex lenses and a smaller double convex eye-lens. Such arrangements resulted in increasing substantially the field of view. Behind the lines was an implicit attack to the microscope used in Vienna. By having a smaller field of view in their microscope, Pettersson and Kirsch were forced to increase the intensity of the source and thus the secondary radiation. Somewhat regretful, Bates and Rogers

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[63] Pettersson refers to Rutherford’s letter in his own on July 27, 1923, AÖAW.
[64] Pettersson to Rutherford, July 27, 1923, AÖAW, (in English)
[65] Pettersson to Rutherford, July 27, 1923, AÖAW, (in English)

pointed out that "the scintillation method is the only method at present available for investigating these long-range particles."[67] They avoided any reference to the Viennese group when, on February 1924, they sent their next study to the *Proceedings of the Royal Society*. More confident this time, Bates and Rogers argued that the long-range particles described in their experiment were emitted by the source itself.[68] Additionally, they had slightly altered the scintillation method by introducing polonium as the radioactive source instead of radium C. There was the significant advantage that polonium did not emit beta rays.

The task of preparing polonium was neither an easy one nor common knowledge between the experimenters. Chadwick, as a senior colleague and greatly interested in the project, prepared for Bates and Rogers the polonium source from a solution of radium D.[69] Eventually, the contamination of the source with radium forced the two research students to use instead the contents of old emanation tubes provided by Rutherford.

While Rutherford enlisted in his group research students who never forgot to acknowledge his support, Pettersson enrolled more experienced experimentalists.[70] Dagmar Pettersson entered the debate on April 3, 1924, presenting her first paper to a meeting in the Vienna Academy.[71] She brought to the Radium Institute technical knowledge and chemical expertise of her recent work at the *Technische Hochschule,* as well as the experience she had gained working with Otto and Hans Pettersson.

6.5. Dagmar Wendel-Pettersson

Daughter of a prosperous civil engineer, Dagmar Pettersson, née Wendel, received private education and entered the University of Uppsala to study chemistry as her major and mathematics as her minor.[72] All of Dagmar's three sisters sought professional training, prompted by their father to ensure a self-supporting life. As the eldest, born in 1888, Dagmar finished her studies in 1914 and soon after got a position

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[66] Bates and Rogers, "Particles of Long Range," (1924), p. 114.
[67] Bates and Rogers, "Particles of Long Range," (1924), p. 114.
[68] Bates and Rogers, "Particles of Long Range from Polonium," (1924), pp. 360-369.
[69] Bates and Rogers, "Particles of Long Range from Polonium," (1924), p. 360.
[70] For example, in their article published in the *Proceedings* in 1924, Bates and Rogers expressed their "best thanks to Sir Ernest Rutherfod who suggested this research and who gave us many helpful suggestions during its progress" (Bates and Rogers, "Particles of Long Range," (1924), p. 116).
[71] Pettersson, Dagmar "Über die maximale Reichweite," (1924), pp. 149-162.

as a chemist in an agricultural laboratory in Skenja, Sweden, playing a leading role in building a new chemistry lab.[73] In the meantime wishing to return to Göteborg and being closer to her parents, she was soon looking for a new position. In the first decade of the 19th century women who sought careers in science in Sweden were very few and quite visible. Thus Dagmar had already met Hans Pettersson in Uppsala, where they both studied, but it was not until her return to Göteborg that they developed a relationship. Hans offered to help by asking his father to hire Dagmar as a chemist in his oceanographic station in Bornö. Otto already had a female chemist assistant and seemed to have been fairly open in accepting women in his lab.[74] After his son's intervention, Otto assigned to Dagmar to measure the salinity of deep water samples as a research assistant at Börno. Two years later, in 1917, Hans and Dagmar got married. When Pettersson moved to Monaco, Dagmar joined him, not only as his wife, but as a colleague with much experience in chemistry.[75] After they finally moved to Vienna in late 1922, Dagmar got a position at the *Technische Hochschule*, Vienna's Polytechnic, working in a lab as a chemist and simultaneously doing research at the Radium Insitute supporting Hans' project.[76] Although in 1923 their three-year old daughter joined them in Vienna, Dagmar was able to continue her work. The fact that her husband was a scientist probably made a difference in her ability to combine motherhood with her scientific research.

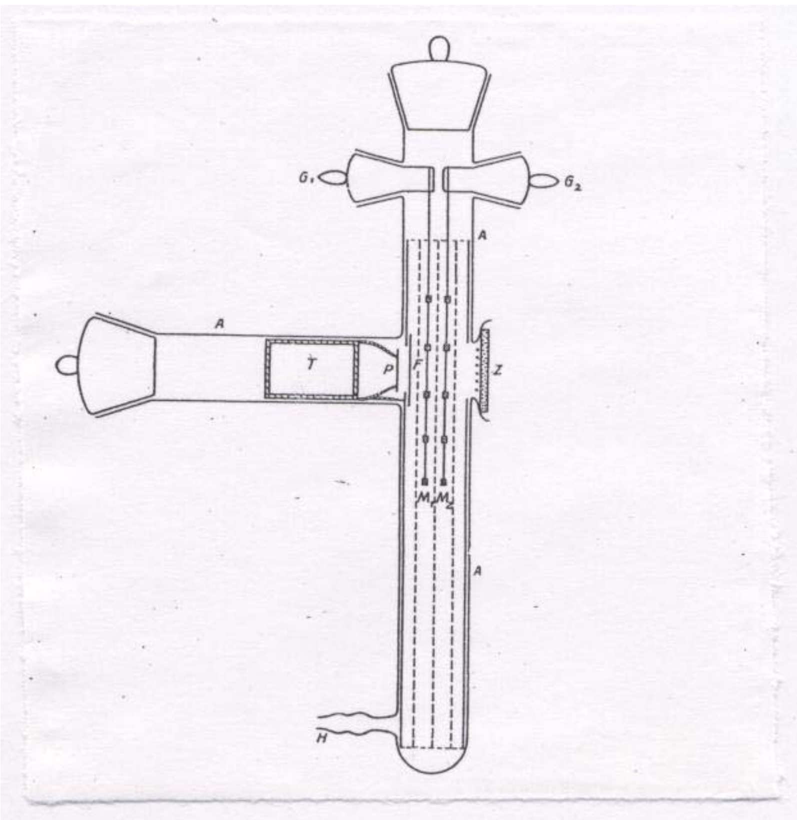
Directly addressing Bates' and Rogers' experiments, Dagmar attempted to undermine their results by altering the scintillation method. Instead of allowing alpha particles to pass through air or mica as in the Bates and Rogers experiments, Dagmar enclosed the scintillation counter in a glass tube. She constructed a device for sending alpha particles emitted from radium C to the scintillation screen through thin foils of gold or of copper, which acted as primary absorbers for the ordinary a-particles.[77]

Dagmar's apparatus consisted of a glass T-tube that directed the alpha-particles emitted from the source to the scintillation screen (Z) passing through the carrier of the radioactive preparation (T). The gold absorbing foil (F) was placed in front of the preparation (P) in order to minimize the risks of getting secondary

[72] Rodhe, interview by the author, September 22, 2001, Göteborg.
[73] Rodhe, interview by the author, September 22, 2001, Göteborg.
[74] Svansson, interview by the author, September 21, 2001, Göteborg.
[75] Rodhe to Rentetzi, October 29, 2001.
[76]Rodhe to Rentetzi, October 29, 2001.
[77] For details on Pettersson's method of the preparation of the radium C source see Stuewer, "Artificial Disintegration," (1985), pp. 248-9.

particles other than those of the source. Additionally, mica screens of varied stopping powers were interposed between the scintillation screen and the source. The mica screens offered the advantage of placing weak radioactive sources closer to the scintillation screen. Two frames (M_1) and (M_2) with five openings each, hanging from (G_1) and (G_2) vertically in the tube, determined the different absorption levels from 0 to 16 cm equivalent of air. The pipe (H) was designed to control the pressure in the tube and a magnetic field deflected the beta rays emitted from the source (see figure 6.1).

Figure 6.1 Dagmar Pettersson's scintillation counter (source: Pettersson, Dagmar. 1924. "Über die maximale Reichweite der von Radium C ausgeschleuderten Partikeln" *Sitzungsberichte Akademie der Wissenschaften in Wien, Mathematisch-naturwissenschaftliche Klasse,* Abteillung IIa, 133: 149-162).



For the preparation of radium C, Dagmar adopted Pettersson's innovative method of using thin capillary tubes filled with radium emanation and dry oxygen.

The microscope used for the observation of the light flashes was, as Dagmar argued, superior to that of Rutherford's and Chadwick's. That gave her the opportunity to observe the slow weak scintillations from H-particles. Used previously by Kirsch and Pettersson, the microscope, directly attached to the scintillation screen, had a numerical aperture of 0.70 and the field of view was decreased from 12.5mm^2 to 8mm^2. [78] "It may be added," as Dagmar argued, "that the use of a greatly improved microscope made it relatively easy to distinguish between scintillations from H and from alpha-particles, so that they could be counted separately."[79] According to the final results, the number of alpha particles of range more than 9.2 was, to the surprise of Bates and Rogers, zero. That meant that there were no long-range alpha particles emitted from the source. Directly addressing Bates and Rogers, Dagmar published her article not only in the *Mitteilungen* but also in *Nature.*[80]

Dagmar's first ambitious article in the world of radioactivity research was actually her last one as well. Shortly after her publication, Rutherford and Chadwick challenged her observations, arguing that it was probably the use of the absorbing foils that misled Dagmar in detecting the long-range alpha particles.[81] Although she continued to work in Pettersson's group, Dagmar did not publish and, according to the recollections of her daughter, "research work never was prominent for my mother."[82] During her stay in Vienna and despite the fact that she had two children, Dagmar remained part of the Institute.[83] Taking advantage of her chemical expertise, her tasks were the extraction and purification of polonium from the Joachimstal radioactive residues.[84] From 1922 to 1926 she appeared in the *Bericht* of the Institute as a collaborator, while she followed Hans to his constant trips between Vienna and Göteborg from 1922 to 1928. It was during those years that Dagmar built warm,

[78] Pettersson, Dagmar. "Über die maximale Reichweite," (1924), p. 153.
[79] Pettersson, Dagmar "Long Range Particles," (1924), p. 642.
[80] Pettersson, "Long-Range Particles from Radium-Active Deposits," (1924), pp.641-42.
[81] Rutherford and Chadwick, "On the Origins and Nature," (1924), p. 509-526.
[82] Rodhe to Rentetzi, October 29, 2001.
[83] Dagmar and Hans hired a Swedish nanny to take care of their kids in Vienna. Sometimes they even brought their daughter to the Institute. Rodhe recalled that during her early years she used to observe the preparation of scintillation screens at the Radium Institute when their parents were busy with their scientific research. She was even taught how to brush the mixture of alcohol and zinc sulfide from the small rectangle glasses used for scintillation counting (Rodhe, interview by the author, September 22, 2001, Göteborg).
[84] Hans Pettersson's report on the investigation regarding artificial disintegration of elements "Atomzertrümerung" carried out during the first half of 1926 in Radium Institute and the second Physics Institute of the University of Vienna, GUA.

friendly relations and close collaborations with the rest of the women that eventually lasted longer than her stay in Vienna.[85]

For example, in order to prepare the settings for her experiments, Dagmar collaborated closely with a young lady, giving rise to Hans Pettersson's later claims for the "unselfish" and collegial ethos of his group.[86] "For the zinc sulfide screen, I thank Elisabeth Kara-Michailova," as Dagmar acknowledged, "which she produced through careful examination of different scintillation substances and methods of preparation."[87] Kara-Michailova was twenty-seven years old with a short but important list of publications already in her vita. At the Academy meeting on May 8, 1924, Kara-Michailova presented a new technique that she and Hans Pettersson had developed for identifying the flashes between alpha and H-particles.[88] Their aim was essentially to reshape the scintillation counter by utilizing a new microscope they had constructed. The result was to deeply alter not only the counter but also the gender assumptions that accompanied its use. Where Cambridge researchers aimed for a well-defined hierarchical division of labor among the experimenters, the Viennese chose a collegial partnership. It was under these assumptions that Kara-Michailova teamed up with Pettersson in 1923.

6.6. The Kara-Michailova—Pettersson Collaboration

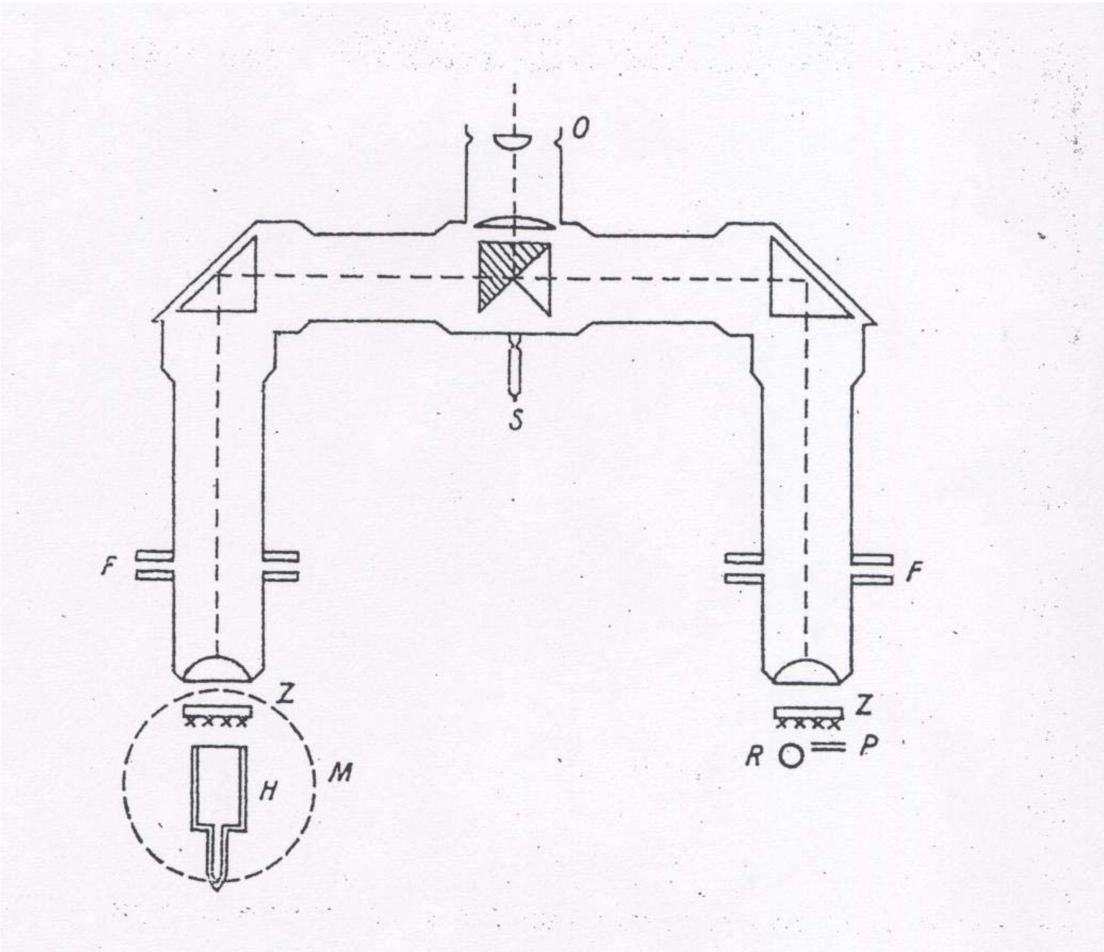
Although both the Vienna and the Cambridge groups had immensely improved the scintillation counter, still its main disadvantage was the difficulty in distinguishing between flashes produced by different kinds of particles. As Pettersson and Kirsch suggested, the considerable differences of the relative brightness of scintillation from alpha and H-particles required more attention and exact measurements.[89] Thus, having an expertise on measurements of luminescence, Kara-Michailova was the most appropriate collaborator for Pettersson.

[85] Blau, Karlik, and Rona occasionally corresponded with Dagmar even after Pettersson's death in the 1970s. They used to recall the pleasant years they spent together in Vienna during the 1920s. As director of the Institute in the 1960s and 1970s, Karlik often conveyed information about their common friends and acquaintances. For example, Karlik reported the death of Georg Stetter's wife and Przibram's 88th birthday in Karlik to Dagmar Pettersson, December 18, 1966, GUA.
[86] Hans Pettersson's report to the International Education Board, April 1928, GUA.
[87] Pettersson, Dagmar. "Über die maximale Reichweite," (1924), p. 153.
[88] Kara-Michailova and Pettersson, "Über die Messung," (1924), pp. 163-168.
[89] Kirsch and Pettersson, " Long-Range Particles," (1923), pp. 394-395.

In early 1924, with the help of his Swedish sponsors, Pettersson purchased a so-called 'Vergleichsokular' (a comparison eyepiece) from the *C. Reichert Company* in Vienna.[90] The eyepiece was designed to compare the images from two microscopes in combination with two Watson holoscopic objectives. For a Watson scintillation microscope, a comparison eye piece for scintillation photometry, two holoscopic objectives, and a number of scintillation screens and absorbing foils, Pettersson estimated the considerable amount of 86 US dollars.[91] In the Radium Institute there was no previous experimental tradition with such an optical system. As a result, Pettersson purchased the whole set, altering not only the scintillation method but the material culture of the Institute as well.

[90] Kara-Michailova and Pettersson, "Über die Messung der relativen Helligkeit," (1924), p. 164.
[91] Hans Pettersson's financial report to the International Education Board, GUA.

Figure 6.2 The Scintillation counter used by Elisabeth Kara-Michailova and Hans Pettersson (source: Kara-Michailova, Elisabeth and Pettersson, Hans. 1924. "Über die Messung der relativen Helligheit von Szintillationen" *Sitzungsberichte Akademie der Wissenschaften in Wien, Mathematisch-naturwissenschaftliche Klasse,* Abteillung IIa, 133:163-168).



As figure 6.2 shows, FOF was the 'Vergleichsokular' with two identical microscopes directly built to the same eyepiece. Those were Watson holoscopic objectives with numerical aperture 0.45 each and focal length 16mm. S was the fixture holding a reflective prism that gave the opportunity to combine the pictures from both microscopes or selectively reflect the picture from only one. The microscope on the left was set to observe the scintillations produced by H-particles on the screen (Z). The source (H) was either radium emanation or radium C and the Leyboldt magnet (M) was set to deflect the beta rays of the source. The microscope on the right was set to observe the flashes of alpha-particles produced by a polonium preparation (P). The zinc sulfide screens scintillated in response to both kinds of particles but the relative brightness of the flashes was determined by means of light-absorbing screens (F) of known absorption.

In the flow of their main text, Pettersson and Kara-Michailova did not forget to acknowledge the help of Maria Belar in measuring the absorption of the gray glasses (F). "We thank Maria Belar for the measurement of the absorption of the individual gray glasses that she has carried out by the means of a Glan spectrophotometer in yellow-green light."[92] At that time, Belar was closely working with Przibram and had just finished her thesis on the spectrophotometric method.[93] The same year, continuing the same line of research, Kara-Michailova, as sole author, published an article in the prestigious *Physichalische Zeitschrift* on the scintillation method and the quantitative optical differentiation between alpha and H-particles.[94] In the autumn of 1925 Kara-Michailova was forced to quit her research for a few months. Suffering from lung infection she moved to Merran, in Tirol, to recover.[95] As her publication record indicates, that interruption cost her more than a year of active work although she actually returned to the Institute in the spring of 1926.

During her absence, Pettersson succeeded in raising more stable funds for his research and the Institute. The International Educational Board awarded an annual grant to the Radium Institute with duration of three years, starting on July 1, 1925.[96] In the autumn of 1925, Pettersson applied to the Board for an additional fellowship. As he argued, that "would enable me not only to pursue my own investigations but also to go on training and supervising a number of younger collaborators who were engaged in important problems related with artificial disintegration."[97] It was this exact same point that Meyer stressed in his own letter of recommendation addressed to the International Education Board. "His [Pettersson's] impulsiveness acts most beneficially on his young collaborators here and he knows excellent how to introduce them to the methods of this difficult subject, so that, also in this respect the object of the Educational Board, that is the higher training of young workers, would be

[92] Kara-Michailova and Pettersson, "Über die Messung der relativen Helligkeit," (1924), p. 165.
[93] Belar, "Spektrophotometrische Untersuchung," (1923), pp. 45-54; Przibram and Belar, "Die Verfärbung," (1923), pp. 261-277.
[94] Kara-Michailova, "Quantitative optische Unterscheidung von alpha und H-Teilchen," (1924), pp. 594-596.
[95] Hans Pettersson to Mellbye, March 7, 1926, (in Swedish, Agnes Rodhe Papers, translated by Rodhe)
[96] Hans Pettersson's report to the International Education Board, April 1928, GUA.
[97] Hans Pettersson's report to the International Education Board, April 1928, GUA.

served."[98] The International Education Board's choices in funding eventually affected and shaped physics research in Europe. The unstable political situation and the financial problems that European researchers were facing made the International Education Board a major actor in deciding physicists' careers and the future of research programs. Pettersson's research group in Vienna and his own career depended substantially on the decisions of the Board.[99] On December 1925, Pettersson informed Meyer that he was finally awarded the fellowship and was planning to return to Vienna with his family.[100]

6.7. Putting the Scintillation Counter Aside

The great disadvantages of the scintillation counter slowly but steadily pushed both the Cambridge and the Vienna laboratories to alter their material culture. As Pettersson reported later, "the subjective character of all observations made by the scintillation method added to the strain on the eyes of the counters which it involves, has made it most desirable to develop novel methods of studying that atomic fragments, less excerting and less subject to errors."[101] As an answer to the Viennese threat of undermining their authority in the field, the Cambridge team employed a Wilson cloud chamber in their research. Although invented in 1895, the Wilson chamber was not incorporated into radioactivity research programs before 1923. As Clinton Chaloner argues, the Wilson chamber gained its impetus from the dispute over the scintillation counting procedures between the Vienna and Cambridge groups.[102]

Rutherford's response to the use of the chamber was enthusiastic and soon the Wilson cloud chamber rendered the paths of particles for the Cavendish people. Pettersson did not want to miss the opportunity of using their instrument to support his own experimental results and theoretical claims. On November 21, 1923, supported financially by the International Education Board, Pettersson ordered a

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[98] Meyer to Trowbridge, October 7, 1925, AÖAW, (in English).
[99] See for example how powerful the Rockefeller Foundation was in the case of the health related work that it funded in central Europe after the First World War. Weindling, "Public Health and Political Stability," (1993), pp. 253-267; Page, "The Rockefeller Foundation and Central Europe," (2002), pp. 265-287. For the case of physics under National Socialism in Germany see Macrakis, "The Rockefeller Foundation," (1989), pp. 33-57.
[100] Pettersson to Meyer, December 4, 1925, AÖAW.
[101] Hans Pettersson's report to the International Education Board, April 1928, GUA, (in English).
[102] Chaloner, "The Most Wonderful Experiment," (1997), p. 364.

Shimizu Wilson ray track apparatus. That was a reciprocating form of Wilson's initial instrument, which enabled more photographs in a second than the initial one. Within less than a month, *The Cambridge and Paul Instrument Company,* later *The Cambridge Instrument Company*, shipped the new apparatus to the Radium Institute in Vienna.[103] A young doctoral student, Rudolf Holoubeck, was assigned to study the tracks of H-particles from aluminum, carbon, and iron using the new instrument.[104]

At the same time a second method, directly from the Cavendish laboratory, was employed by the Vienna Institute. Georg Stetter, *Assistent* at the second Physics Institute and collaborator with the Radium Institute, constructed a mass spectrograph, adopting the principle used by Francis William Aston in England.[105] A young research student, Norbert Kreidl, developed a third technique, an electrical counter based on Greinacher's original discovery.[106] In the early part of 1925, funded by the International Education Board grant, Kreidl spent two months in Greinacher's laboratory in Bern for training.[107] In 1926 Stetter and Gustav Ortner took over the research, designing a method of electrical amplification of ionisation currents that operated a loud-speaker.[108] The development of a fourth technique was assigned to Blau. In early 1924 she focused on the use of photographic emulsions and studied the photographic effects of H-particles.[109] As Pettersson wrote to his sister in March 7, 1926, "by indescribable tenacity, she [Blau] has succeeded at an almost hopeless job I suggested to her two years ago."[110] Her first attempt was to observe recoil protons produced by alpha particles in parafin. With weak radioactive sources she could also

[103] The Cambridge and Paul Instrument Company to Pettersson, December 18, 1923, GUA. For more on the marketing of cloud chambers see Chaloner, "The Most Wonderful Experiment," (1997), pp. 365-367.
[104] Holoubek, "Der Nachweis," (1927), pp. 321-336; Holoubek, "Die Sichtbarmung," (1927), pp. 704-720.
[105] For Aston's mass spectrograph and the rest of the Cambridge techniques adopted in Vienna see Hughes, *The Radioactivists,* (1993). Also Pettersson, "On the Investigations," (1926), GUA.
[106] Hans Pettersson's report to the International Education Board, April 1928, GUA; Kreidl, "Zur Verwendbarkeit des Geiger'schen," (1927), pp. 589-602. Greinacher developed a method for producing sound in a telephone by individual particles. See Greinacher, "Über die akustische Beobachtung," (1924), pp. 361-378.
[107] Hans Pettersson's report to the International Education Board, April 1928, GUA.
[108] Ortner and Stetter, "Die Hörbarmachung von H-Strahlen," (1927), pp. 70-72. See also Hughes, *The Radioactivists,* (1993), p. 118. For the interference of Stetter and Ortner to Kreidl's project see Pettersson to Meyer, August 28, 1927, AÖAW.
[109] Blau, "Über die photographische Wirkung," (1925), pp. 427-436; Blau, "Die photographische Wirkung," (1925), pp. 285-295; Blau "Über die photographische Wirkung," (1927), pp. 469-480; Blau, "Über die photographische Wirkung," (1928), pp. 751-764; Blau, "Über photographische Intensitätsmessungen von Polonium," (1928), pp. 259-268.

observe the lower energy particles. The only strong source available was polonium, which Rona knew how to prepare. As Blau describes, "to prevent darkening of the plate by gamma radiation, one worked with polonium, which was prepared by Dr. E. Rona in highly concentrated preparations. After a tedious series of indefinite experiments, it finally worked in 1926, and in the following year the method could be applied to the disintegration of various atoms with alpha particles."[111]

Apparently, besides designing new apparatus for tracing particles, the Vienna group was in need of radioactive sources, preferably polonium, which was extensively used in the artificial disintegration experiments. Irene Curie was one of the few experts within the radioactivity community who could extract and prepare polonium sources. The process involved the tiresome task of the chemical separation of the element, its purification, and the final concentration on a small surface.[112] Since polonium did not emit beta particles that usually interfered in scintillation counting, its use as a radioactive source was most advantageous. Used mainly in the Wilson chamber experiments, the Viennese group was anxious to obtain the technical expertise for preparing polonium sources.[113] In May 1926, Pettersson reported to his father that "I have now managed to get Meyer to write a letter to Curie asking to send one of our scientists, Frau Doctor Rona, chemist and specialist in polonium, to her lab for three weeks in order to learn the art from Irene Curie…If she is allowed to go, we have no problems next year and can make our own polonium samples."[114] Probably drawn from his own problems with the Curies, Pettersson added, "I first had an idea of going myself but desisted for the reason that a man coming to the Paris lab will be getting a much less friendly welcome than a woman."[115] His father, using most likely his authoritative way, had already tried to persuade Curie to accept his son in her lab just a few years earlier but she refused.[116] Nevertheless, Curie accepted Rona when,

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[110] Pettersson to Mellbye, March 7, 1926, (in Swedish, Agnes Rodhe Papers, translated by Rodhe). For a detailed account of Blau's work related to photographic emulsions see Galison, *Image and Logic,* (1997), pp. 146-160.

[111] Blau, curriculum vitae, Leopold Halpern Papers, (in German, Ruth Sime provided an English translation)

[112] Rona, *How it Came About,* (1978), p. 22.

[113] As Pettersson reported in 1926, the use of a strong polonium source in Holoubek's experiments enabled him to take less photographs than Blackett did by working on the same method in Cambridge. (Pettersson, "On the Investigations," (1926), GUA).

[114] Hans to Otto Pettersson, May 24, 1926, (in Swedish, Agnes Rodhe Papers, translated by Rodhe).

[115] Hans to Otto Pettersson, May 24, 1926. (in Swedish, Agnes Rodhe Papers, translated by Rodhe).

[116] Rodhe, interview by the author on September 22, 2001, Göteborg. Pettersson's uncomfortable relations with the Curies deteriorated when he visited their institute in Paris in 1936. Commenting on his letter that described the situation, Karlik suggested that "you must remember, too, what queer

not surprisingly, Pettersson succeeded in obtaining a small grant from a Swedish sponsor that funded her trip.[117]

6.8. Elisabeth Rona: "The Polonium Woman"

Rona, known as "the polonium woman,"[118] was probably the most experienced experimenter among the members of Pettersson's group. She was born in 1890 in Budapest to a prosperous Jewish family.[119] Her father, Samuel Rona, a physician who had close contacts with L. Wickham and H. Dominici, the founders of radium therapy in Paris, was influential in introducing the field in Budapest.[120] Growing up in a stimulating environment, Rona studied physics at the University of Budapest and pursued further graduate studies at the University of Karlesruhe, in Germany, with a focus on physical chemistry. In the meantime she spent a few months at the chemical division of the Institute of Animal Physiology in Berlin.[121] It was finally in Karlesruhe where she was introduced to radioactivity research by Kasimir Fajans, a Polish radiochemist, who was working on radioactive isotopes.[122] In the spring of 1914, after having development a strong friendship with Fajans that lasted for years, Rona spent a summer in England working in Ramsay's group.[123]

During the First World War Rona was in Hungary working with Georg von Hevesy, who had just left the Institute for Radium Research in Vienna to accept the position of lecturer at the University of Budapest.[124] His work on radioactive elements as tracers of chemical reactions attracted Rona's interest. Her collaboration with Hevesy placed Rona among the key figures of the radioactivity community, such as Rutherford, Frederic Soddy, Alexander Fleck, Hahn, and Meitner. At the time Hevesy got involved in one aspect of a controversy concerning the production of isotopes and

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people they are. As regards Irene I don't think you should feel puzzled by anything she does. Her manners are really perfectly intolerable" (Karlik to Pettersson, April 9, 1936, GUA).

[117] Pettersson, "On the Investigations," (1926), GUA.

[118] Rayner-Canham, M. and Rayner-Canham, G. "Elisabeth Rona," (1997), pp. 209-216.

[119] Bischof, *Frauen am Wiener Institut,* (2000), p. 121.

[120] Rona, *How it Came About,* (1978), p. 2.

[121] During that time Rona published in the *Journal of Biochemistry*. Rona, "I: Über die Reduktion; II: Vergärung," (1914), pp. 137-142.

[122] Sime, *Lise Meitner,* (1996), pp. 49-50. On Fajans controversy with Frederic Soddy on radioactive isotopes see Merricks, *The World Made New,* (1996), p. 49-50.

[123] Rayner-Canham, M. and Rayner-Canham, G., "Elisabeth Rona," (1997), p. 210.

[124] Levi, *George de Hevesy,* (1985).

their relationship to the periodic table.[125] Antonoff, a Russian research student working with Rutherford in Manchester, claimed to have isolated uranium Y, an unknown element. Soddy and Fleck, unable to repeat his experiments, engaged in a public and fierce dispute with Rutherford's student. Hoping to apply his radioactive tracer method to the problem, Hevesy asked Rona to repeat the controversial experiment. She succeeded in separating the uranium Y from all the interfering elements and proved that it was a beta emitter with a half-life of 25 hours. "Soon after my paper was published by the Hungarian Academy of Science," as Rona recalls, "Soddy, Hahn, and Meitner also verified Antonoff's results."[126] The next year she and Hevesy published a paper in the prestigious *Zeitschrift für Physikalische Chemie.*[127] The collaboration ended when Hevesy left Budapest in 1918. Yet Rona was already an experienced scientist on the border zone of chemistry, physics, and biology. Her earlier work in Berlin and her knowledge of chemistry qualified her for a job she was eventually offered by Francis Tangl, a biochemist and physiologist at the University of Budapest. Tangl needed a scientist to set up complementary courses in chemistry for his medical students and Rona fit the description. Nevertheless, her task did not last long. The communist revolution in 1919 and the political upheavals that followed forced Rona to resign in 1921, unable to bear the overload of work caused by the depletion in staff.[128]

At the time the radioactivity community was small enough for researchers to be noticeable and international enough to promote mobility and scientific exchanges among different Institutes. Rona's work, first with Fajans and then with Hevesy, offered her such visibility in the community that Hahn provided her a grant and an opportunity to work with him and Meitner at their radioactivity department of the Kaiser Wilhelm Institute in Berlin-Dahlem.[129] During the two years of her stay, Rona became proficient in separating thorium-230 from uranium ores and when the economic situation in Germany deteriorated, she was transferred to the Kaiser

[125] While Soddy was involved in a dispute with Fajans concerning the group displacement laws that defined the production of radioactive isotopes, a second dispute related to the first, arose between Soddy and the British group working in Manchester (Merricks, *The World Made New,* (1996), p. 48).
[126] Rona, *How it Came About,* (1978), p. 8. See also Hahn and Meitner, "Über das Uran Y," (1914), pp. 236-240.
[127] Hevesy and Rona, "Die Lösungsgeschwindigkeit," (1915), pp. 294-305.
[128] Rona, *How it Came About,* (1978), p. 10. While Rona taught at the University of Budapest, she did not quit her research. In 1920 two articles came out based on her earlier work with Hevesy. Rona, "Über die Wirksamkeit," (1920), pp. 279-89; Rona, "Diffusionsgrösse," (1920), pp. 62-65.
[129] Rona, *How it Came About,* (1978), p. 10.

Wilhelm Textile Institute. As she explained, "only institutions whose research was important to the nation's economy could receive grants."[130] When her grant in Berlin and the political turmoil in Hungary were over, Rona finally returned to Budapest in 1923. She had already gained experience not only in radioactivity but also in industrial chemistry and textile technology as well. This knowledge guaranteed her a position in one of the biggest textile industries in Hungary. Given the economic situation in Europe and the low status of women in academia, Rona was right, arguing that "industry offered some hope."[131] The cruelty, though, of the industrialists and the lack of research opportunities forced her to resign in a year. Unemployed, Rona joined her family in the Austrian resort in Bad Ischl for summer holidays in 1924. It was there that Stefan Meyer offered her a position at the Radium Institute in Vienna. With the credential of working with some of the most important members of the radioactivity community, Rona enter the Institute during the academic year 1924/1925.[132] Adopting the methods of Pettersson's group on February 10, 1926, she presented to the Austrian Academy of Sciences her work on improved methods for measuring the absorption and range of H-rays and the use of polonium as a more suitable source than radium C. The main instrument she used was the scintillation counter.[133] She teamed up with Blau and worked on the ionization of H-rays.[134] Four months later, after Pettersson's persistent attempts, Rona arrived at Curie's institute to get trained in preparing polonium sources.[135] On Rona's return to the Radium Institute a few weeks later, Curie was generous enough to donate to the Viennese a strong polonium source concentrated on a small silver disc of $12mm^2$. Most of the following studies on artificial disintegration performed at the Institute were done either using Curie's source or Rona's preparations.[136]

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[130] Rona, *How it Came About,* (1978), p. 14.
[131] Rona, *How it Came About,* (1978), p. 14.
[132] Almanach der Akademie der Wissenschaften, (1925), pp. 216, AÖAW.
[133] Rona, "Absorptions und Reichweitenbestimmungen," (1926), pp. 117-126.
[134] Blau and Rona, "Ionisation durch H-Strahlen," (1926), pp. 573-585.
[135] Rona to Meyer, June 3, 1926, AÖAW. The letter was sent from Paris.
[136] Pettersson, "On the Investigations," (1926), GUA.

6.9. The Scintillation Counter as a Cultural Hybrid

In the midst of the busiest times in the Radium Institute with Pettersson's group working feverishly on new, more reliable techniques for counting particles produced by atomic disintegrations. Kara-Michailova went further into the design and construction of the scintillation counter. On May 5, 1927, she presented her next scintillation study to the Vienna Academy.[137] The focus was on the brightness of scintillations produced by H-particles in relation to their velocity. As she pointed out, the most important question for the application of the scintillation method was to determine the lower limit of particles' velocity at which the scintillations were noticeable to the observer. Kara-Michailova's steps in designing her new experiment involved a noteworthy exchange of instrument parts with Stetter's mass spectrograph.

Although in search of other methods, Stetter and his colleagues were still faithful to the scintillation counter. By modifying Aston's mass spectrograph, Stetter was first to replace the photographic plates with Pettersson's and Kara-Michailova's model of the scintillation counter.[138] Purchased in 1926, Stetter's new apparatus was far too costly, close to $140, when for example Kara-Michailova's annual salary for the same year was a bit more than double that.[139] Thus, replacing the photographic plates with the old, familiar scintillation screens and a microscope was not a matter of cutting down in expenses. Rather it was an expression of loyalty to the material culture of the Institute. Most of all it revealed the commitment of the Viennese group to an experimental tradition that trusted the co-worker and his or her report instead of the static, visual representation of phenomena on photographic film. Yet the transfer in instrument parts went both ways. "I am obliged to many thanks to Herrn Dr. Stetter," as Kara-Michailova acknowledged in her paper "for letting me use his apparatus as well as for his help with the research."[140] Literally from her working bench to Stetter's and back again, the transformation of the instrument was indicative of a dying experimental culture. Based on the fragile eyesight of the observer, the scintillation counter was put aside as experimenters sought for more trustworthy and

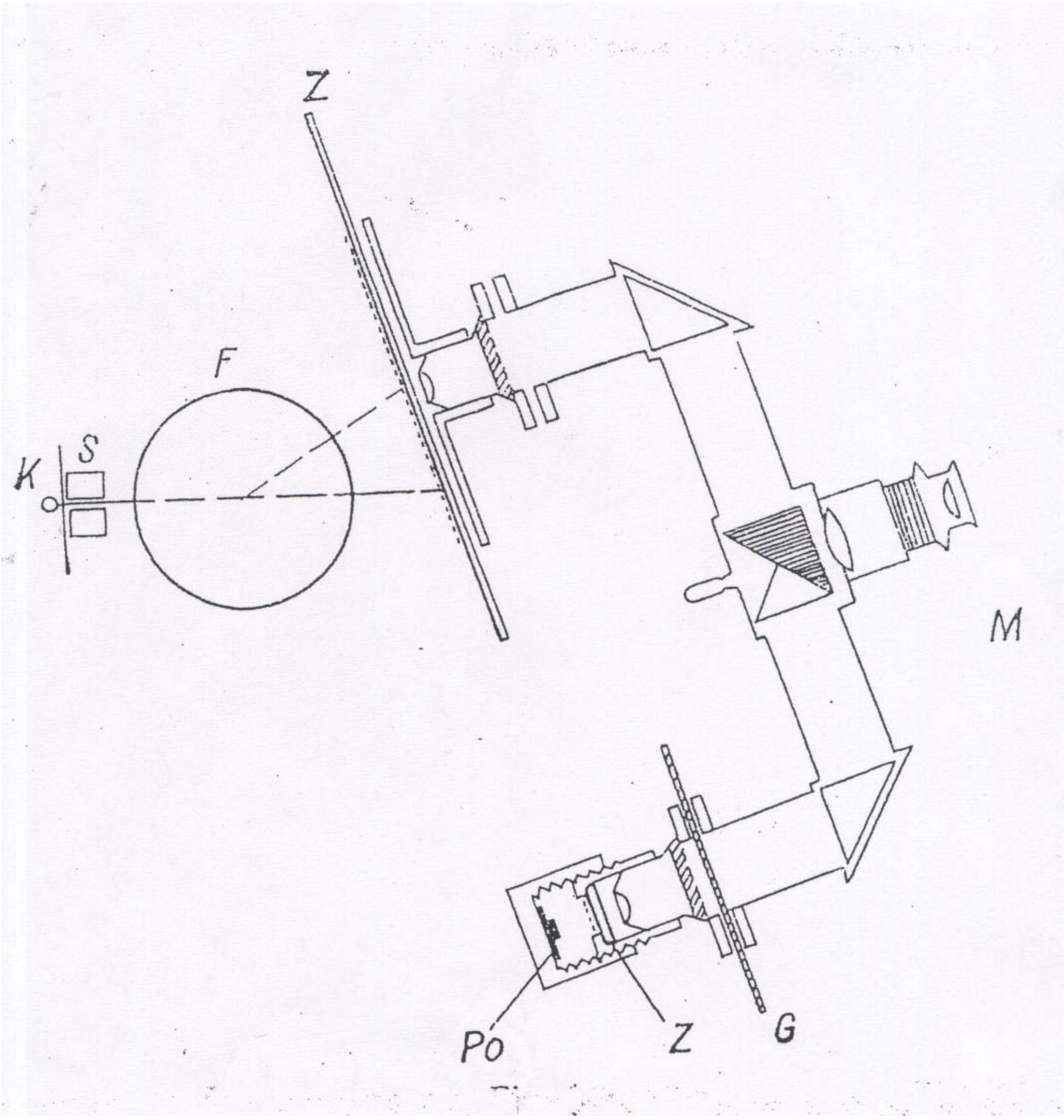
[137] Kara-Michailova, "Helligkeit und Zällbarkeit der Scintillationen," (1927), pp. 357-368.
[138] Stetter, "Die Massenbestimmung von H-Partikeln," (1925), pp. 158-177; Stetter, "Die Bestimmung des Quotienten Ladung/Masse," (1926), pp. 61-69; Stetter, "Massenbestimung," (1926), pp. 735-738; Stetter, "Die Massenbestimung," (1927), pp. 741-758; Stetter, "Die neueren Untersuchungen," (1927), pp. 712-723; See also Hughes, *The Radioactivists,* (1993), p. 107.
[139] Hans Pettersson's report to the International Education Board, GUA.
[140] Kara-Michailova, "Helligkeit und Zählbarkeit," (1927), pp. 359-360.

objective methods of research.[141] The replacement of human observers by mechanical devices indicated a shift in the material culture of the laboratory. Struggling to survive the transformation, the Viennese experimenters constructed instruments as hybrids at the intersection of the two material cultures.

By working in Pettersson's group, Kara-Michailova shared a strong network of collaborators in preparing radioactive sources such as polonium (Po), constructing scintillation screens (Z), and measuring the absorption of gray glass (G) used in determining the ratio in the brightness of the scintillations. With the comparison microscope, Kara-Michailova was able to observe the scintillations of both alpha and H-particles as she was used to in her previous experimental settings. The new feature was the magnetic field (F), which separated H-particles according to their velocity. Therefore only rays of the same velocity fell upon the scintillation screen (Z). (K) was the radioactive source and (S) the gap through which the rays were directed towards the magnet. This part of the device was enclosed to a vacuum (see figure 6.3).

[141] For a historical account of the notion of objectivity see Daston and Galison, "The Image of Objectivity," (1992), pp. 81-128.

Figure 6.3 The scintillation counter used by Elisabeth Kara-Michailova in 1927 (source: Kara-Michailova, Elisabeth. 1927. "Helligkeit und Zällbarkeit der Scintillationen von magnetische abgelenkten H-Strahlen verschiedener Geschwindigkeit" *Sitzungsberichte Akademie der Wissenschaften in Wien, Mathematisch-naturwissenschaftliche Klasse,* Abteillung IIa, 136: 357-368).



During the preparation and the performance of her experiments, Kara-Michailova acted as the experienced and mature researcher on scintillation counters, having total control over her instruments. She employed two groups of trained observers in order to report simultaneously the scintillations produced by alpha and H-particles. The microscope in use had two Watson objectives of numerical aperture 0.70 and a single eyepiece. According to Kara-Michailova's results the brightness of the H-particles was proportional to their residual range. The lower velocity limit for observing them was found to be less than 10^9 cm/sec.

While Kara-Michailova's sought to improve the scintillation measurements, Pettersson visited Cambridge in May 1927. His long discussions with Blackett and Chadwick were centered on the scintillation method. On May 16, the discussion opened up with a reference to the properties of scintillation substances and the fatigue of the observers. As Pettersson argued, his colleagues in Vienna counted for 30 seconds or often for 20 seconds instead of one minute as the Cambridge observers did.[142] Both Pettersson and Chadwick placed an enormous importance on what essentially was Kara-Michailova's project, the possibility of distinguishing between flashes of alpha and H-particles using the scintillation counter. As it turned out the resolution of the whole controversy was based on this distinction and, in the hope of arriving to a conclusive settlement, Chadwick planned a visit to Vienna in December 1927. Up to that point Kara-Michailova, Blau, and Rona had come a long way in designing their instruments and their experiments. Their role in the wake of Pettersson's research group was indeed instrumental.

6.10. Being a Woman Experimenter in Vienna

During the 1920s what it meant to be a physicist specialized in radioactivity strongly depended on the culture within which such an identity was constructed and performed. To be a physicist of the British group it meant to accept the hierarchical structure that Rutherford's authority imposed and work on assigned projects that designed to maintain this authority. Students' training was strictly organized around the accepted research methods of the laboratory and maintained the local experimental culture. In their hands the scintillation counter was the most important

[142] "Discussion on atomic disintegration in Cambridge," May 16, 1927, GUA.

instrument for experiments on artificial disintegration. Having access to affluent resources, the British, nonetheless, were able to develop alternative techniques and sustain their focus on first rate research when the counter proved to be unreliable. In Vienna, although Pettersson was the leading experimenter, he encouraged teamwork and exercised less control over the pace and direction of research in his group. As he describes the rituals of his group "The papers are circulated in manuscripts and read by all the co-workers and thoroughly criticized by them before publication."[143] Instead of a common training in the research methods of their laboratory, the Viennese chose the review of their peers as a way to construe experimentation in their local context. Those who joined the group were mainly experienced experimenters who entered the Institute attracted by the new, fascinating research topic or were already working there. Placing this picture into the cultural and political context of Red Vienna, it is not surprising that many women joined the group, while in Cambridge no women appear either as counters or as experimenters. These different social conditions in the two laboratories provided also different ways to make, put in use, and sustain the scintillation counter.

In Vienna the instrument was "disciplined" according to the local material resources, the expertise of the personnel, and their professional needs. In the hands of the Viennese the transformations of the scintillation counter reflected a unique loyalty to the machines through which women maintained their status at the Institute. From their published work it becomes obvious that the women of the Vienna group did not enter the field of radioactivity as technicians and laboratory assistants to their male colleagues. Instead they participated in the group as experimenters with deep knowledge of their instruments. Blau, Rona, and Kara-Michailova forged professional careers through their participation in Pettersson's group and research students such as Erna Bussecker, Theodora Kautz, and Selma Schneidt gained their doctoral degrees. During the 1920s the instruments used in radioactivity research were table-top, portable apparatus and easy to construct from scratch. Being able to transfer a single part of a laboratory technology from one workbench to another, women were also able to negotiate their existence in the discipline. Their practices and styles of behavior were integrated to their lived experiences as experimenters in the Vienna group, experiences that pointed to an exceptional cultural and scientific setting. It was

[143] Hans Pettersson's report to the International Education Board, April 1928, GUA.

James Chadwick’s visit in Vienna in 1927 and the resolution of the controversy that for the first time posed an obvious threat to women’s identities as experimenters.

CHAPTER 7
THE OUTCOME OF THE CAMBRIDGE-VIENNA CONTROVERSY: FROM THE GENDERING OF SKILLS TO THE CROSSING OF DISCIPLINARY BOUNDARIES

Besides a place for scientific production, the laboratory is definitely a space of work where tasks are labeled as skilled and unskilled, and positions are divided to those paid monthly and those supported by grant money or by research fellowships. This perspective of the laboratory as a system of labor opens up interesting questions. How are different roles assigned to the laboratory practitioners? Who decides which positions are designated as skilled and how laboratory resources are distributed among scientists? What kind of role does gender play in the designation of a task as skilled or unskilled? What is the role of gender in the crossing of disciplinary boundaries, carrying knowledge outside of the laboratory limits?

In the case of the Radium Institute, as I have argued in chapter five, both the director and the politics of Red Vienna influenced the gender profile of the Institute in such a way that women accounted for the one third of the total number of the researchers. As the study of specific cases reveals, scientists fashioned roles in the Institute that fit with their expertise, while, at the same time, those roles shaped the kind of expertise they actually pursued. For example, Kara-Michailova joined Pettersson's group as a young physicist brining with her the knowledge she obtained working with Przibram. Assuming the role of Pettersson's close collaborator in the comparative study of the brightness of alpha particles and protons, she soon developed into an experienced experimenter.

Most of the women working in the core research group of the Institute, nonetheless, were paid through the grant money that Pettersson brought in, and by performing photographic tasks or preparing radium sources for the needs of hospitals and other institutes. Although some managed to obtain the position of *Assistentin* or that of *wissenschaftliche Hilfscratf* in the Institute, for the most part, women were not able to get into the academic hierarchy. On the contrary, most of the men held stable positions as university assistants and professors. Thus, although the division of labor within the Institute was fairly gender equal, the surrounding academic structure was closed to women.[1]

Focusing on the material culture of the Vienna Institute, I argued in chapter six that women decisively shaped its research agenda. Having control over their instruments and designing their own experiments, women such as Blau, Rona, Dagmar Pettersson, and Kara-Michailova each left a strong imprint on the course of the controversy between Cambridge and Vienna. Why is it then that these women are known as technicians and as those who were blamed for the outcome of the controversy? Through the eyes of the sociologist of science Jan Golinski, the women who participated in the dispute between the two laboratories were the "support stuff" that "bore the responsibility for worrying discrepancies in observations."[2] As he argues, "this was found to be more agreeable solution than blaming the physicists on either side, presumably at least in part because the technicians were not consulted and their judgment could more easily be doubted."[3] All of the women, nevertheless, who were part of the lengthy exchange of publications in the 1920s studied physics, had a background in mathematics, and had experience in experimental physics. Golinski echoes Achinstein's and Hannaway's argument that, in the Radium Institute, "a division of labor had separated the eyes of the observers from the minds of the experimenters."[4]

By working with Roger Stuewer's precise historical account of the episode, the above historians and sociologist jump to a conclusion that Stuewer never argues for.[5] He not only reports on women's scientific work but is willing to look more carefully at Chadwick's interpretation of a derogatory comment on women's work supposedly made by Pettersson. As Stuewer argues, "Pettersson valued his co-workers highly, and they him, and hence it is not clear in what tone of voice he made these remarks."[6] What Stuewer did nevertheless was to write the story of the dispute between the two laboratories from the point of view of the male protagonists. Rutherford, Chadwick, Pettersson, and Kirsch did have their fair share in the historical plot and, although acknowledging some of the women, Stuewer left them on

[1] This does not come as a total surprise. The same patterns occurred at some of the institutes of the Kaiser Wilhelm Society in Germany for a variety of reasons. See Vogt, "Women Members of the Academies of Science," (2000), pp. 1-24.
[2] Golinski, *Making Natural Knowledge,* (1998), p. 90.
[3] Golinski, *Making Natural Knowledge,* (1998), p. 90.
[4] Achinstein and Hannaway, *Observation, Experiment, and Hypothesis,* (1985), x.
[5] Stuewer, "Artificial Disintegration," (1985), pp. 239-307.

the margins of his narrative. Their absence is what permits accounts such as Golinski's, Achinstein's, and Hannaway's. Thus, the history that separates the female 'technicians' from the male 'experimenters' in the Radium Institute leads us back to the main question of this chapter: how are skills actually gendered?

7.1. James Chadwick's Visit to Vienna

After Pettersson's visit to Cambridge in May 1927, for a moment things seemed settled and the relations between the two laboratories seriously improved. As director of the Institute, Meyer took the initiative to thank Rutherford for the warm hospitality with which he accepted Pettersson in Cambridge. In an attempt to clear up any misunderstandings, he assured Rutherford that what was at issue was certainly not his authority in the field. "We hope that you got the impression that Dr. Pettersson and his coworkers here are doing their best to improve the knowledge founded by you on the atomic disintegration and that they are trying to further the work in the most serious attempts and not to trouble the advancements."[7] Chadwick's visit had already been arranged for December that same year.

Indeed, hoping to resolve the disagreements between the two laboratories, Chadwick arrived in Vienna on December 7, 1927.[8] A scrutiny of the scintillation screens and the most basic aspects of the artificial disintegration experiments persuaded Chadwick that the problem resided in the Viennese protocol of scintillation counting.[9] As Hughes interprets Chadwick's thoughts, "there only remained the possibility that the Viennese were mistaken in believing that they could distinguish between scintillations due to alpha-particles and those due to H-particles by the

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[6] Stuewer, "Artificial Disintegration," (1985), p. 287-88.
[7] Meyer to Rutherford, May 25, 1927, AÖAW, (in English).
[8] During the summer of 1927, before Chadwick's arrival in Vienna, Bates visited unexpectedly the Institute. The research was slowed down and most of the personnel were absent. Pettersson had just returned from Sweden. This is how he described the visit to Meyer who at the time was in his summer residence in Bad Ischl, upper Austria: "yesterday I was surprised from a visit, a gentleman with a lady. That was our old enemy Dr. L. F. Bates, who I had shortly met in London" (Pettersson to Meyer, August 28, 1927, AÖAW). Pettersson gave him and his wife a tour at the Institute and they discussed in a "friendly tone." It was so friendly that Bates mentioned to Pettersson their Cambridge stock in capillary spent radon tubes from hospitals used in the preparation of polonium. Pettersson did not miss the opportunity. He immediately prompted Meyer to ask Rutherford for a small radon tubes supply (Pettersson to Meyer, August 31, 1927, AÖAW).
[9] For a detailed description of Chadwick's visit see Stuewer, "Artificial Disintegration," (1985), 239-307; Hughes, *The Radioactivists,* (1993); Brown, *The Neutron and the Bomb,* (1997).

difference in brightness, a practice which the Viennese vehemently defended."[10] Precisely it was Kara-Michailova who "vehemently" defended her method in front of the scintillation counter and during the replication of the experiments. She was among the "young ones" who stood around "stifflegged and with bristling hair" as Chadwick vividly described it.[11]

Friday December 9 "ended up with a fierce and very loud discussion."[12] Apparently, Chadwick intended to step on Pettersson's territory and question his authority in his own laboratory. As he reported to Rutherford, "it is essential that I should prepare the experiment. So far, I cannot get Pettersson to agree to this."[13] Chadwick had probably suppressed the fact that when Pettersson visited Cambridge a few months earlier he treated him as a tourist. As Hughes put it, Pettersson indeed remained a "disengaged witness" in his antagonist's territory.[14] Similarly, during the first two days of his visit Chadwick was tenaciously kept away from the scintillation screens and the microscopes. On Monday December 12, however, Chadwick took advantage of Pettersson's absence and, treating the personnel as inexperienced students, he assumed control at the Institute.[15] "Today I arranged that the girls should count and that I should determine the order of counts. I made no change whatever in the apparatus, but I run them up and down the scale like a cat on a piano—but no more drastically than I would in our own experiments if I suspected any bias. The result was that there was no evidence of H-particles."[16]

Chadwick's bias probably did not concern the experimental techniques, but instead the women experimenters. Here is how he described to Rutherford the testing of Schmidt's apparatus—disintegration of carbon by polonium a-particles. "Their counters, two girls, managed to find a few [scintillations]."[17] The shift from "experienced observers," in Rutherford's language, describing scintillation counting in his lab,[18] to "girl counters," in Chadwick's report of the work done in Vienna is more than a naïve linguistic slip in reference to the same task. Instead, it indicates the

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[10] Hughes, *The Radioactivists,* (1993), p. 112.
[11] Hughes, *The Radioactivists,* (1993), p. 134.
[12] Stuewer, "Artificial Disintegration," (1985), p. 285.
[13] Stuewer, "Artificial Disintegration," (1985), p. 285.
[14] Hughes, *The Radioactivists,* (1993), p. 136.
[15] As Chadwick wrote to Rutherford, Pettersson's whole family came to visit him in Vienna (Stuewer, "Artificial Disintegration," (1985), p. 287).
[16] Stuewer, "Artificial Disintegration," (1985), p. 286.
[17] Stuewer, "Artificial Disintegration," (1985), p. 286.
[18] Rutherford, Chadwick, and Ellis, *Radiations from Radioactive Substances*, (1930), p. 550.

gendering of skills. The counting of scintillations, so crucial for the early experiments on artificial disintegration, was treated as a highly skilled task of experimental observations when performed by Rutherford's male team in the Cavendish lab. Chadwick considered the same task, performed in the Viennese setting by the women experimenters, to be disconnected from observation and its meaning to the experimental process. As he noticed, "not one of the men does any counting. It is all done by three women."[19] The immediate inference was that those women were mere counters. Apparently, the three women were Kara-Michailova, Blau, and Rona.[20] All of them were active participants in the controversy. Besides Kara-Michailova's work on the scintillation method, Rona was the polonium expert in the Institute and the one who introduced Schmidt to the technique of preparing polonium sources while they worked on the penetration of polonium to metals.[21] Further, in collaboration with Blau, she employed polonium to the study of ionisation of H-rays.[22] Blau had been working on the alternative method of photographic emulsions.[23] What Chadwick saw, however, was routine counting and, as he later acknowledged, "the young women were perfectly honest."[24] His presupposition, though, legitimized the way Achinstein and Hannaway interpreted the episode in 1985.[25] Indeed, Chadwick suspected that women were informed about the experiments in advance and "they were seeing what they expected to see."[26] The minds that designed the experiments were, in Chadwick's account, separate from the eyes that recorded the results. Women's skills were limited to counting, recording, and following orders from their male colleagues.

If one asks whether Chadwick's version of the work in Vienna was entirely his interpretation, the answer is no. Pettersson seems to have his share in this wrong account. According to Chadwick, "Pettersson says the men get too bored with routine work [meaning the scintillation counting] and finally cannot see anything, while women can go for ever."[27] In the intense environment of the replication of the experiments it is plausible that Chadwick and Pettersson misunderstood each other. A

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[19] Stuewer, "Artificial Disintegration," (1985), p. 287, excerpt from Chadwick's letter to Rutherford on December 12, 1927.
[20] Pettersson to Kerr Grant, December 29, 1927, GUA.
[21] Rona and Schmidt, "Untersuchungen," (1927), pp. 65-73.
[22] Blau and Rona, "Ionisation durch H-Strahlen," (1927), pp. 573-585.
[23] Blau, "Uber die photographische," (1925), pp. 427-436.
[24] Brown, *The Neutron and the Bomb,* (1997), p. 88.
[25] Achinstein and Hannaway, *Observation, Experiment, and Hypothesis,* (1985).
[26] Brown, *The Neutron and the Bomb,* (1997), p. 88.
[27] Stuewer, "Artificial Disintegration," (1985), p. 287.

stiff Englishman "completely lacking a sense of humor,"[28] he had difficulties in understanding the humor of a Bohemian Swede.[29] Moreover, it is hard to reconcile the above claim either with Pettersson's anti-hierarchical style as the research leader of his group or with the respect he paid to his colleagues. Writing his report to the International Board of Education in 1928, Pettersson used language that surprises the reader even today. "Each collaborator has *his or her* (emphasis mine) particular share to take in making the practical preparations necessary for an experiment. Besides each has *his or her* (emphasis mine) particular theme for research which he pursues and where he can count on the help from one or more of his fellow workers."[30] Appraising his experience of working in Vienna, Pettersson continues, "I have learned the very high value of team work for attacking such intricate problems as are met within the comparatively new field of nuclear physics."[31]

In this collegial atmosphere, Kara-Michailova had already adopted the research on scintillation counters as her main project contributing her part to Pettersson's team. Clearly she did a great deal more than to count scintillations in front of a microscope. As I have argued in chapter six, Kara-Michailova was actually the one who, in collaboration with Pettersson, had altered the optical system to suit the needs of the experiment. Additionally, she offered her expertise in fluorescence and lighting measurements in order to improve the method and distinguish between alpha and H-particles, an essential issue in the Cambridge-Vienna controversy. She even introduced trained observers in her experiments, proving the seniority of her position within the team.[32] As an experienced experimenter she had absolute control of her instrument, knowing its tricks better than any of her male colleagues. Apparently, scintillation screens were easily prepared in the Institute. The procedure was as easy as spreading zinc sulfide over a glass screen and brushing it out very smoothly. Kara-Michailova was also skilled in experimenting with different scintillating substances and preparation methods. The manipulation of the numerical aperture and the field of view of the microscope were also within her capacity. Obviously, she had control over every single part of the scintillation apparatus and was able to take the whole tabletop instrument apart and reconstruct it from scratch.

[28] Rona, *How it Came About,* (1978), p. 20.
[29] This is how Rodhe characterized her father (Rodhe, interview by the author, September 22, 2001, Göteborg).
[30] Hans Pettersson's report to the International Education Board, April 1928, GUA.
[31] Hans Pettersson's report to the International Education Board, April 1928, GUA.

Thus, to count the scintillations was not a secondary, routine task for Blau, Rona, or Kara-Michailova. On the contrary, what Chadwick failed to recognize was that all these tasks were their own responsibility and part of their identity as experimenters in the Institute. Chadwick was too absorbed by his own struggle supporting the Cavendish experimental results to understand the teamwork involved.

Let us suspend the narrative for a moment. Focusing on laboratory technologies and gender in the two laboratories, it becomes apparent that there is a shift in the epistemological meaning of the concept of skill from an objectively quantifiable quality to an ideological category assigned to men and women on the grounds of gender biases. As the study of the scintillation counter reveals, the definition of a position as 'skilled' depends on the gender identity of the person performing it. For example, even though Rutherford considered the male experimenters of his team as experienced observers, Chadwick saw the women in the Vienna Institute as mere counters of flashes. It is needless to repeat that the performed experiments in both cases required identical skills from the experimenter's part. Therefore, skill becomes political concept in the laboratory life and plays a central role in maintaining the gender division of labor.[33] Scientists and even historians of science are more inclined to see women as users than as designers of the technologies they encounter in their everyday laboratory practice.

Back to the story, Kara-Michailova's effort, overall, was to secure a method that, although highly important in the 1910s and the beginning of the 1920s, was then at its end as radioactivity was rapidly heading towards nuclear physics. An essential member of her research group, she had a "volcanic energy" in the peak of the controversy, as Pettersson admitted.[34] Yet passion for scientific work was not enough. With the total monthly budget of 250 US dollars coming from the Rockefeller grant, Pettersson was trying to manage his entire research team.[35] It was therefore worth trying to save the cheap scintillation counter. A microscope with a couple of lenses, scintillation screens, and absorbing foils, was priced not more than 86 US dollars, while a Wilson chamber lamp alone cost 14 US dollars.[36] Low cost was not the only advantage of the scintillation counter. For Kara-Michailova and the rest of

[32] Kara-Michailova, "Helligkeit und Zählbarkeit," (1927), pp. 359-360.
[33] I owe my thanks to Peter Galison for his valuable suggestions on the concept of skill.
[34] Pettersson to Mellbye, March 7, 1926, (in Swedish, Agnes Rodhe Papers, translated by Rodhe).
[35] Pettersson to Mellbye, March 7, 1926, (in Swedish, Agnes Rodhe Papers, translated by Rodhe).
[36] Hans Pettersson's financial report to the International Education Board, GUA.

Pettersson's team, to save the method meant to retain control over the material culture of their laboratory. For instance, as a young research student, Karlik was one of those who focused on saving the instrument.

Two months before Chadwick visited the Vienna Institute in 1927, Karlik defended her thesis to Meyer and Hans Thirring.[37] Not surprisingly, given the importance of the scintillation method, Karlik's topic was the dependence of scintillations on the condition of zinc sulfide and the nature of the scintillation process.[38] She described a photometric method for determining the relation between the range of alpha-particles and the brightness of the scintillations for differently prepared zinc sulfide screens. In her effort to defend the scintillation method, Karlik introduced photographic plates in her model of the counter. In order to reduce the light entering the eye through the microscope she placed photographic plates between the objective and the eyepiece.

Especially innovative, the Viennese group was characterized by their attempts to save an old technique by taking advantage of the elements and instrument parts of new ones. Their colleagues in Cambridge were clearly shifting from the old, shaky laboratory technologies that the scintillation counter represented to the new, persuasive evidence of the photographic plates. Instead, the Viennese were hesitantly swinging between the two worlds, transferring pieces of instruments from one workbench to another and persistently defending the old physics experimental tradition that the scintillation counter belonged to. The portable, tabletop scintillation counter which almost all of the Viennese experimenters in Pettersson's group could control and construct, offered them a feeling of security, not only in the fast moving world of radioactivity research, but also in the politically unstable Viennese setting.

7.2. The Politics of a "Private" Resolution

When Chadwick met Meyer in the latter's office at the Radium Institute on December 14, 1927, to discuss the awkward outcome of his visit in Vienna, what ensued was anxiety on both sites. Chadwick had demonstrated that the Viennese researchers had been performing unreliable experiments using the scintillation

[37] Karlik's exams for her major in physics were on October 10, 1927 and for mathematics on January 13, 1928. She finally graduated on March 8, 1928, (Rigorosenakt 9765, AUW).
[38] Karlik, "Über die Abhängigkeit der Szintillationen," (1927), pp. 531-561.

technique. Meyer offered, on the other hand, a public acknowledgment of Chadwick's results. In this odd situation, Chadwick counteroffered a private resolution following Rutherford's earlier wish to "better discuss these divergences of view in private than in print."[39] At issue were not only the fame of the Vienna Institute and the authority of Cambridge. Equally at stake was the reliability of the scintillation counter.[40]

For at least the next two years the scientific community remained largely unaware of the outcome of the Cambridge-Vienna controversy.[41] Although the scientific credibility of the Radium Institute and its researchers were not widely affected given the private resolution of the episode, Pettersson's team collapsed financially. The Radium Institute was already in such bad shape that a month before Chadwick came to Vienna Meyer raised the issue of the radium that the Austrian Academy of Sciences had lent Rutherford before the war.

> Austria is so impoverished, that neither the government nor private persons or societies here are in the position to keep our Institute going without financial help from abroad. For the last three years we were assisted by the International Education Board; but as the Board no longer wishes to continue the appropriations to us our funds are threatening to run down so that we must try to get money from somewhere else, if this Institute is to be able to go on working. So I take the liberty of asking you if you could manage to raise the necessary funds for buying the rest of the Radium that you have in Cambridge perhaps in ten or fifteen years installments? The market price of Radium is at present $70 for 1 mg, but I am sure that our Academy would be willing to accept a lower price.[42]

In his response, Rutherford said he was willing to discuss the matter with the university authorities. He argued, though, that the amount of radium was only 250mg and not 304mg that Meyer proposed.[43] Excerpts of old notes of Rutherford's "radium book" provided evidence for his claim. By offering his own data, Meyer questioned Rutherford's estimations. But since the Institute was in desperate need of financial help he concluded, "as there are too many uncertainties, and that is to avoid all difficulties, I immediately at the beginning proposed to accept your estimation of

[39] In a letter of July 19, 1924, Rutherford suggested Pettersson to resolve their differences in private. "Workers in this field" as he argued "are too few and too select to misunderstand one another." (Hughes, *The Radioactivists,* (1993), pp. 138-9. Stuewer, "Artificial Disintegration," (1985), p. 256).
[40] Hughes, "Modernists with a Vengeance," (1998), p. 351.
[41] Hughes, *The Radioactivists,* (1993), p. 206; Brown, *The Neutron and the Bomb,* (1997), p. 88; Weiner, Sir James Chadwick, oral history, AIP.
[42] Meyer to Rutherford, November 8, 1927, AÖAW.
[43] Rutherford to Meyer, November 23, 1927, AÖAW.

251mg as basis of all further negotiations."[44] While Chadwick was still in Vienna, Meyer had the chance to discuss the issue thoroughly with him. On December 21, 1927, immediately after Chadwick's return to Cambridge, Rutherford settled the matter. "I am very sensible of the generosity shown by the Vienna Academy of Sciences and the Austrian Government in loaning me such a valuable preparation for such a long period…Please let me know if the price of purchase (3000 pounds) and the mode of payment by installments is satisfactory to you."[45]

As Meyer already knew, the International Education Board was not going to renew Pettersson's own fellowship and during 1929/30 the Radium Institute received the last payment of 1,500$ from the Rockefeller Foundation.[46] In a letter to his sister in 1928 Pettersson described his dreadful life in Vienna:

> My colleagues have been touching at looking for somewhere to live for us. The Pension Atlanta would have been too costly. We are now renting two rooms in the flat of an elderly lady in Döbling, a quite, country-like suburb of Vienna. With time we have been able to worm ourselves into the lady's confidence, even using her kitchen for making lunches. For dinners we have found a good, simple Gasthaus at the Silbergasse. Dinner for three, amounts to less than 5 shillings, that is 2.5 sek. So, the affluent times of Rockefeller are gone. Kara(Michailova) who helped much in getting us rooms, also has put in quite a supply of butter, marmalade, bread, eggs, and oranges, welcoming us at our arrival on Good Friday. Gerhard Kirsch's sister had put flowers in both rooms and from Blau and Rona there were Easter eggs and a set of Dominoes for Anne.[47]

Unable to continue his research without the Rockefeller grant, Pettersson eventually returned to Sweden. According to Stuewer, "The entire investment collapsed to the ground in a few short days in December 1927. It was a severe shock."[48] The tragic picture that Stuewer draws does not do justice to the collaboration that followed Chadwick's visit to Pettersson and his colleagues in

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[44] Meyer to Rutherford, November 29, 1927, AÖAW, (in English).

[45] Rutherford to Meyer, December 21, 1927, AÖAW. Hughes argues that Meyer agreed with Rutherford's terms not only because he was financially desperate but also because he was embarrassed by the outcome of Chadwick's visit (Hughes, *The Radioactivists,* (1993), p. 141). The letters exchanged before Chadwick's visit, nonetheless, show that Meyer had already agreed with Rutherford's terms. On the contrary, it was Rutherford who seems to have been embarrassed after Chadwick's visit to Vienna.

[46] Almanach der Akademie der Wissenschaften, (1930), p. 235, AÖAW.

[47] Pettersson to Mellbye, April 15, 1928, (in Swedish, Agnes Rodhe Papers, translated by Rodhe). As Rodhe recalled, "I can remember those dinners for two, each parent scratching morsels onto my extra plate" (Rodhe to Rentetzi, October 29, 2001).

[48] Stuewer, "Artificial Disintegration," (1985), p. 290.

Vienna. It was not until 1936 that as Karlik wrote, to him "to think that this has been your last regular visit as regards our collaboration in atomic physics is very sad. I can hardly realize it yet. This joint work has been so much the center of my interests for the past years that it will mean quite a readjustment of my inner life to get adapted to the new circumstances."[49] Acknowledging Pettersson's role in her career, Karlik added, "it's you who have shown me what experimental physics really are; if I look back I must say I had only a very faint idea of it before I began working with you."[50]

Chadwick's visit, though, led Pettersson to a different kind of tragic circumstances than the immediate collapse of his work with the Viennese. The defeat for Pettersson was personal since he lost the battle over his father's wishes.[51] In 1928 he was refused a professorship of physics at the University of Stockholm.[52] Instead, his father Otto arranged money for a new professorship, this time on oceanography in Göteborg.[53] Pettersson never gave up his interest in radioactivity research but he also never acquired a position in physics. After years of attempts to avoid his father's influence, Pettersson had to rely on him once more for his academic career. It was not until 1934 that he admitted to Karlik, "I am of course aware that I am counted out before the physicists of Europe, 'suspect d'otre suspect' a position I do not mind so much personally but which is of course unfortunate for the work."[54]

The Cambridge group, financially and scientifically, remained on the top of the game. Early in 1928, Rutherford aware, of the importance of wave mechanics to radioactivity, succeed in getting a new position for a teacher in theoretical physics and also additional money to organize a conference on beta and gamma rays.[55] As Andrew Brown argues, "the main purpose of calling the conference was for Rutherford, Chadwick, and Ellis to make sure they had not left anything important out of their forthcoming book."[56] The conference, nevertheless, was also a forum where the Cambridge team planned to restore their authority in the field of radioactivity after the lengthy exchange of papers in the scientific press with the Viennese. Moreover, they intended to do so undisturbed by their main opponents. Although they invited all the

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[49] Karlik to Pettersson, March 28, 1936, GUA, (in English).
[50] Karlik to Pettersson, March 28, 1936, GUA, (in English).
[51] Rodhe, interview by the author, September 22, 2001, Göteborg; Svansson, interview by the author, September 21, 2001, Göteborg.
[52] Hughes, *The Radioactivists*, (1993), p. 158.
[53] Svansson, interview by the author, September 21, 2001, Göteborg.
[54] Pettersson to Karlik, September 27, 1934, GUA.
[55] Hughes, *The Radioactivists,* (1993), pp. 132, 152.
[56] Brown, *The Neutron and the Bomb,* (1997), p. 96.

key figures of the radioactivity community, it was not fortuitous that from the Radium Institute in Vienna only one participant attended the meeting. Ewald Schmidt, even though he was not the one to work on the central theme of the conference, was the one to receive an invitation.[57] Other young researchers who had worked on radioactivity in general attended the conference, yet the young Viennese who played essential role in the controversy such as Kara-Michailova, Karlik, and Blau, or the men of the group such as Kirsch, Holoubek, and Ortner, were silently excluded.[58] Especially Blau would have been a perfect fit. She had completed a dissertation on the absorption of gamma rays and she had already a long list of publications and experience in the alternative method for detecting radiation, the photographic emulsions.[59] Thus, what the Cambridge group avoided through a public acknowledgment of the episode, they actually better accomplished through the politics of exclusion. It was not the credibility of the researchers that was affected but rather the possibility of their presence in the scientific community.

Suspecting this early on, Pettersson tried to prevent it in vain. As a gesture of a good will he sent Rutherford a spinthiroscope of his design for showing the hydrogen particles from paraffin. The gift was intended to temper the anxiety and tension that surrounded Chadwick's visit and ensure that Pettersson's powerful antagonists would not affect his own and his colleagues presence in the radioactivity community. In his thankful response Rutherford added, "There are so few workers in this difficult subject that we must try and pull together and settle our differences as far as possible by private correspondence rather than by controversies in scientific journals, which in my experience do nothing but cause irritation. If you and your friends are of the same opinion I think there should be no great difficulty in settling our differences. During my whole scientific career I have not had any serious controversy and always advise my students to be considerate where differences of opinion are involved."[60] Even though the dispute was indeed settled in private, the group at the Radium Institute was finally dissolved. Partly because of the silent exclusions that the Cambridge team imposed on them and partly because of financial difficulties, most of the members

[57] Hughes, *The Radioactivists,* (1993), pp. 152-157. Chadwick to Meyer, June 23, 1928, AÖAW.
[58] The only other person that Chadwick thought of inviting was Stetter. However, as he mentioned to Meyer, "our funds were not sufficient" (Chadwick to Meyer, June 23, 1928, AÖAW).
[59] Blau, "Uber die Absorption divergenter," (1918), pp. 1253-1279.
[60] Rutherford to Pettersson, January 9, 1928, GUA.

were soon scattered to other laboratories, abandoning their teamwork on artificial disintegration.

7.3. The Last Attempt to Save the Scintillation Counter

In May 1928 Karlik teamed up with Kara-Michailova in a last attempt to save the scintillation counter. At a meeting in the Vienna Academy of Sciences they presented their co-authored paper on the luminescence caused by alpha particles and its relation to their energy.[61] For the first time the luminescence produced by alpha particles emitted from polonium was measured by means of the photoelectric current of a rubidium cell. Their next co-authored paper appeared the same year in the prestigious *Zeitschrift für Physik*.[62] Besides discussing the experimental details of the relation between the brightness of the scintillation and the energy given up from the alpha particles of the source, they suggested a theoretical hypothesis in explaining the mechanism of the scintillation process. They were concerned with more that manipulating the instrument, preparing and gauging the scintillation screens, and experimenting with several different elements. They went one step further, suggesting that the zinc sulfide possesses distinct points that are already in an active condition before they are struck by the particles. Theory and experiment came together in the study of the scintillation counter.

At the end of 1928, Kara-Michailova was promoted to the position of *Wissenschaftliche Hilfscraft* at the Institute.[63] She was obviously the mature partner in her collaboration to Karlik, although the latter's work came to the center of attention of the Cambridge group in November 1928. Julius Chariton and C. Lea, two of Rutherford's research students, raised objections to Karlik's dissertation project, published a year earlier. As they argued, there was a considerable difference between the results obtained by Karlik and their experiments concerning the question of how the amount of light entering the eye from an individual scintillation affects the number of total scintillations observed. Probably the discrepancies were due to "the device used for reducing the fraction of the light from a scintillation which entered the

[61] Karlik and Kara-Michailova, "Über die durch alpha-Strahlen erregte Lumineszenz," (1928), pp. 363-380.
[62] Karlik and Kara-Michailova, "Zur Kenntnis der Szintillationsmethode," (1928), pp. 765-783.
[63] November 6, 1928, Karlik's file, Mitarbeiter/Assistenten, AÖAW.

eye."[64] Chadwick communicated the paper to the Royal Society in November 1928. But not only Karlik's results were at stake. During his visit in December 1927 Chadwick was able to show empirically that the Viennese were wrong in the number of scintillations they were claiming to count.[65] Chariton and Lea offer a theoretical explanation of the mistake. The Viennese were actually testing the role of the numerical aperture and the magnification of the microscope designed and used by the Viennese group. It became obvious that the scintillation counter was in its last days.[66] As Rona described Chadwick during his visit to Vienna in 1927, "probably he was just as uncomfortable in the role of the judge as we were in that of the judged."[67] Indeed, under judgment were equally the scintillation technique and the skills of the women experimenters working in Pettersson's group.

Karlik and Kara-Michailova insisted on saving the scintillation counter and presented their last co-authored paper in July 1929 to the Vienna Academy.[68] This time the focus was on the brightness of the scintillations produced by H-particles. Besides Karlik's two subsequent articles in 1930 related to the scintillation technique, none of the Viennese physicists followed up on scintillation counter research, and hardly any publication on it appeared in the *Mitteilungen* of the Institute after 1930.[69] Eventually both women who played a central role in improving the counter abandoned the technique as the center of their research focus. Kara-Michailova teamed up with Blau and worked on the penetrating radiation of polonium.[70] She retained the position of scientific assistant until March 1933, when she applied to the Austrian Federation of University Women for a Yarrow Scientific Research fellowship.[71] Stefan Meyer willingly provided her a reference letter, stating that Elisabeth had been an "independent and stimulated researcher." "She has decisively

[64] Chariton and Lea, "Some Experiments Concerning the Counting of Scintillations," (1929), p. 336.
[65] For the resolution of the controversy see Stuewer, "Artificial Disintegration," (1985), pp. 239-307; Hughes, *The Radioactivists,* (1993).
[66] In a letter of June 23, 1928, Chadwick asked Meyer if he would facilitate Chariton's visit to Vienna. Chariton was in his way to Russia and because of visa restrictions he was not allowed to cross Austria without a reason. "If the authorities are assured by a resident in Vienna of the purpose of his visit, they will be satisfied" as Chadwick explained to Meyer. "His [Chariton's] work has been on the counting and scintillations and I think" as Chadwick continued "you will be interested in what he has to say" (Chadwick to Meyer, June 23, 1928, AÖAW). However, it is interesting that in Chariton's case, Chadwick does not ask for permission but, somewhat haughtily assumes that his student should be welcomed in Vienna.
[67] Rona, *How it Came About,* (1978), p. 20.
[68] Kara-Michailova and Karlik, "Über die relative Helligkeit," (1929), pp. 581-587.
[69] Karlik, "Uber die Szintillationsfähigeit," (1930), pp. 319-326; Karlik, "Untersuchungen zur Lumineszenz," (1930), pp. 509-519.
[70] Blau and Kara-Michailova, "Über die durchdringende Strahlung," (1931), pp. 615-622.

cooperated especially in works on disintegration, on problems of luminescence and also on the remaining time of radium emanations to the human body, without her name always appearing at the publications."[72] Soon after, Kara-Michailova was awarded the fellowship and starting in 1935 spent four years at the famous Girton Women's College.[73] As her later publication record indicates, she crossed once more from physics to medicine, carrying over her expertise in instrument making.[74]

A fellowship from the International Federation of University Women allowed Karlik to spend some time away from the Radium Institute. During the academic year 1930/31, she moved to William Bragg's laboratory in London.[75] Her research interests were centered on crystallography and the use of x-rays in the study of the structure of crystals. It was her knowledge of radiophysics that Karlik brought to Bragg's laboratory, grouping with the crystallographers Ellie Knaggs and Helen Gilchrist.[76] The scintillation counter was in the past for both Karlik and Kara-Michailova, as it was for the research groups in Cambridge and Vienna.

7.4. The Consequences of the Cambridge-Vienna Controversy

Further consequences of the Cambridge-Vienna episode ranged from the entrance of other research centers into the field as the study of the atomic nucleus became a promising area of scientific investigation, to the development of new experimental methods. On the one hand, as Hughes describes, three key groups turned to the study of atomic nucleus.[77] Gerhard Hoffman and his student Heinz Pose studied artificial disintegration at the Physics Institute of the University of Halle, using a polonium source sent by Meyer.[78] In Paris, Maurice de Broglie turned his well-

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[71] Bischof, *Frauen am Wiener Institut*, (2000), p. 96.
[72] Meyer to the Austrian Federation of University Women, September 26, 1933, AÖAW, (in English).
[73] On October 26, 1935, Kara-Michailova wrote to Meyer from Girton College, Cambridge, to thank him for the pleasant years she spent at the Institute. She hoped for further collaboration in the future. (Kara-MIchailova to Meyer, October 26, 1935, AÖAW).
[74] Kara-Michailova, "The Radioactivity of the Water Sources," (1960), pp. 152-162; Kara-Michailova and Kamburov, "Radiological and Hidrological Research," (1961), pp. 109; Kara-Michailova, Nikolov, and Doitchinova, "The Radioactivity of Mineral Water-Springs," (1962), pp. 2-10. As Tsoneva-Mathewson, and the Rayner-Canhams argue, Kara-Michailova organized her own laboratory at the University of Sofia and many of the instruments were handmade. (Tsoneva-Mathewson; Rayner-Canham, M. and Rayner-Canham, G., "Elizaveta Kara-Michailova," (1997), p. 206).
[75] Lintner, "Berta Karlik, Nachruf," (1990), p. 306.
[76] Karlik and Knaggs, *Tables of Cubic Crystal Structures,* (1932); Karlik and Gilchrist, "Separation of Normal Longchain Hydrocarbons," (1932), p. 1992.
[77] Hughes, *The Radioactivists,* (1993), p. 206.
[78] Hughes, *The Radioactivists,* (1993), p. 222.

equipped laboratory for x-ray research into a center for radioactivity studies, and Madame Curie started to accumulate polonium for research on artificial disintegration. On the other hand, the need to replace the scintillation counters with a more reliable technique led to the extensive use of the cloud chamber in Cambridge.[79] Simultaneously, the development of electric counting methods for measuring alpha particles in Rutherford's laboratory secured quantitative investigations and prompted Stetter and Schmidt from the Vienna Institute to focus on the valve amplifier technique.[80] Both the Cambridge and the Vienna institute, nonetheless, were anxious to use polonium as a strong source of alpha particles for their alternative to the scintillation methods. The Cavendish laboratory had no radiochemist. Thus, before Chadwick left Vienna, as Rona recalls, "he extended Rutherford's invitation to me to join the staff at Cavendish Laboratory."[81] Rona chose to stay in Vienna. Retaining her interest in working with polonium, she played a part in each of the new attempts to develop alternative to the scintillation counter techniques at the Institute in Vienna.[82]

Given that Rona's expertise was highly in demand by different researchers and used in a number of newly developed methods for detecting radiation, she moved from one laboratory bench to another, forming collaborations with remarkable flexibility. In 1928, with the help of Ewald Schmidt, she modified P. Bonet-Maury's method for the vaporisation of polonium.[83] In 1930, while Blau was already working on photographic emulsions, the two women brought together their expertise in the study of the H-rays using strong polonium sources and recording the tracks on photographic plates.[84] With Karlik's return from England in 1932, Rona was able to

[79] Chaloner, "The Most Wonderful Experiment," (1997), pp. 357-374; Brown, *The Neutron and the Bomb,* (1997), p. 88.

[80] Hughes, *The Radioactivists,* (1993), p. 157; Schmidt and Stetter, "Die Anwendung," (1929), pp. 271-287; Schmidt and Stetter, "Die Ionisastion," (1930), pp. 123-138; Schmidt and Stetter, "Untersuchungen," (1930), pp. 139-150.

[81] Rona, *How it Came About,* (1978), p. 22. To reconcile Chadwick's invitation to Rona with his account of the work in Vienna, I suppose that most probably in his mind Rona was a good technician having a skill that he could use for the experiments in his own group. On the contrary, as Przibram was fully aware of her research, he described Rona as the chemist of his group referring to the time that she worked on a joint research project with Karlik, Haberlandt, and Przibram on the fluorescence of fluorides (Przibram, "1920 bis 1938" (1950), p. 32).

[82] According to her autobiography, instead of Chadwick's invitation to join the Cavendish, Rona visited Paris in 1928 (Rona, *How it Came About*, (1978), p. 23). However, her first visit to Paris was in 1926 according to her letter to Meyer on June 3, 1926 (AÖAW) and Pettersson's letter to his father the same year (Rodhe to Rentetzi, October 19, 2001).

[83] Rona and Schmidt, "Eine Methode zur Herstellung," (1928), pp. 103-105. The same article appeared in the *Zeitschrift für Physik,* (1928), pp. 784-789. On Bonet-Maury's method see Bonet-Maury, "Sur la vaporisation du polonium," (1927), pp. 1376-1378; Bonet-Maury, "Sur la vaporisation du polonium," (1927), pp. 204-6.

[84] Blau and Rona, "Anwendung der Chamie'schen photographischen Methode," (1930), pp. 275-279.

carry her knowledge of preparing polonium to another workbench. Abandoning the ordinary scintillation counter, Karlik worked on the determination of the alpha particle ranges utilizing a photoelectric cell while she kept the fluorescent screen intact as part of the instrument.[85] In collaboration with Rona, she applied her method to the study of the ranges of alpha-particle emitted from actinium and polonium.[86]

In 1934 Meyer received a telegram from the Joliot-Curies announcing their discovery of artificial radioactivity. In his usual kind manner of appreciation, Meyer invited them immediately to Vienna to present their startling work. As Rona recalls "I had the opportunity to hear a first-hand report about this fundamental discovery, which was to have such far-reaching consequences for different branches of science. The talk was given by Irene Joliot-Curie."[87] During their visit, Rona and Karlik entertained the couple in the Vienna outskirts. Before the Joliot-Curies left the city, they invited Rona to Paris to work on artificial radioactivity, a chance that she did not miss. This time, however, her stay was not without problems. Soon her health deteriorated.[88] As Pettersson wrote to her in July 1934, "we had no idea that you were sick in France."[89] While Gleditsch advised her to pay attention to her health before it was too late,[90] Meyer reminded her that indeed, "the most important thing in life remains always health."[91] All of them must have been shocked by Marie Curie's death on July 4 that year from pernicious anemia.[92] Rona probably was touched the most, since she was still in Paris the day of Curie's death.[93] Eventually, Rona recovered and returned to the Institute the following fall. She carried over to the Radium Institute experimental knowledge on artificial radioactivity, which she introduced to her colleagues in Vienna. Forming a group with Ernst Föyn, Gleditsch's assistant from Sweden, Kara-Michailova, who was still there, and Pettersson, Rona studied the

[85] Karlik, "Eine Lumineszenzmethode," (1933), pp. 115-119.
[86] Karlik and Rona, "Untersuchungen der Reichweite," (1933), pp. 121-126; Karlik and Rona, "Untersuchungen uber die Reichweite," (1934), pp. 217-221.
[87] Rona, *How it Came About,* (1978), p. 33.
[88] Already in February 1934 Pettersson mention Rona's blood problems in his letter wishing quick recovery (Pettersson to Rona, February 24, 1934, GUA. The letter was sent to Vienna).
[89] Pettersson to Rona, July 29, 1934, GUA.
[90] Gleditsch to Rona, August 19, 1934, AÖAW.
[91] Meyer to Rona, September 12, 1934, AÖAW, (translation mine).
[92] Crossfield, "Irene Joliot-Curie," (1997), p. 114.
[93] Rona to Meyer, July 4, 1936, AÖAW.

effects of bombarding radioactive isotopes with neutrons.[94] In 1936, joined by Elisabeth Neuninger, she investigated the artificial radioactivity of thorium.[95]

Blau was still working on photographic emulsions. As she described her research strategy, "the grain thickness of proton tracks was appreciably smaller than that of alpha tracks, and it was evident that the photographic conditions (emulsion characteristics and development conditions) would have to be improved if high energy protons—with smaller ionization thickness—were to be observed."[96] In spite of her close collaboration over the years with Rona, who provided her with stronger radioactive preparations, and the investigation of the penetrating radiation of polonium in collaboration with Kara-Michailova, she did not succeed in making fast protons visible with the photographic technique.[97] The low intensity of radiation limited the accuracy of the measurements. What proved to be decisive for Blau's career and the credibility of the photographic emulsions was their exposure to cosmic radiation on high Austrian mountains. This time Blau's collaborator was Hertha Wambacher.

Nine years younger than Blau, Wambacher had a similar education. She went to the same *Volksschule* (elementary school) as Blau in the first district of Vienna and entered the private *Mädchen Obergymansium* in 1914.[98] In contrast to Blau's Jewish family, Wambacher's was Catholic. Her father, Ferdinand Wambacher, was an industrialist and thus able to ensure her studies at the elite gymnasium and later on in the department of physics at the University of Vienna.[99] Although she enrolled in the chemistry department in the fall semester of 1922, she soon quit for health reasons. She eventually studied law and then moved into physics.[100] According to Leopold Halpern, Wambacher did her *Praktikum* at the Radium Institute working closely with Blau on the improvement of the photographic method. Since Blau did not hold any

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[94] Föyn, Kara-Michailova, and Rona, "Zur Frage der Künstlichen Umwandlung," (1935), p. 159; Föyn, Pettersson, and Rona, "Künstliche Umwandlung," (1935), p. 391. Föyn came to the Institute at the end of 1934, after Gleditsch's arranged his visit with Meyer. He remained there for a year and worked closely with Rona (Meyer to Gleditsch, August 18, 1934, AÖAW; Gleditsch to Meyer, August 30, 1934, AÖAW; Meyer to Rona, September 12, 1934, AÖAW; See also Almanach der Academie der Wissenschaften, (1935), p. 196; (1936), p. 213, AÖAW).
[95] Rona and Neuninger, "Beiträge zur Frage," (1936), pp. 479-482.
[96] Blau, curriculum vitae, Leopold Halpern Papers, (in German, Ruth Sime provided an English translation). See also Blau, "Bericht über die Entdeckung," (1950) pp. 53-57.
[97] Blau and Kara-Michailova, "Über eine durchdringende," (1931), pp. 615-622.
[98] Hertha Wambacher, curriculum vitae, Rigorosentakt, 10860, AUW. The school attracted the girls from the Viennese upper class and bourgeoisie and, not surprisingly, included more than 35 percent Jewish pupils (Anderson, *Utopian Feminism,* (1992), p. 31).
[99] Bischof, *Frauen am Wiener Institut*, (2000), p. 137

position at the University of Vienna, she was not able to advise a student officially. Blau's help, though, was indispensable to Wambacher for completing her dissertation on the impact of photographic desensitizers to the imprints of alpha, beta, and gamma rays on photographic plates.[101] In 1931 Wambacher published her work in the *Mitteilungen,* arguing mainly that the organic dye pinakryptol yellow functioned as a desensitizer on photographic emulsions while with chromic acid the effect was smaller.[102] The first co-authored paper with Blau appeared in June 1932 and a month later the two women were able to detect photographically protons liberated by neutrons.[103] As Galison describes, their result was "bizarre and counterintuitive."[104] Particles liberated by neutrons did not leave an imprint unless the photographic plates where desensitized by means of pinakryptol yellow.[105] As a consequence of this first success in photographically detecting the ionization protons and explaining the effect of desensibilisation, Blau was invited by the German photographic giant Agfa, "as their guest of honor," and a medal was bestowed upon her by the Photographic Association.[106] Additionally, in the fall of 1932 Blau received a scholarship from the Association of Austrian Academic Women and spent the next six months at Robert Pohl's physics institute in Göttigen.[107] In 1933 she accepted an invitation from Marie Curie to spend the rest of her stipendium time at the Institut du Radium in Paris. During her absence, Wambacher teamed with Kirsch on an investigation of neutrons from beryllium using Blau's photographic method.[108] On Blau's return in 1934, neither the Institute nor Vienna was the same. The political upheavals of 1933 had deeply affected both.

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[100] Hertha Wambacher, curriculum vitae, Rigorosenakt, 10860, AUW.
[101] Halpern, interview by the author, March 5, 1999, AIP. See also Blau to Pettersson, September 25, 1933, GUA.
[102] Wambacher, "Untersuchungen," (1931), pp. 271-292.
[103] Blau and Wambacher, "Uber das Verhalten," (1932), pp. 467-74; Blau and Wambacher, "Uber Versuche," (1932), p. 180. In the fall, Blau and Wambacher presented a second lengthier paper on the same topic (Blau and Wambacher, "Uber Versuche II," (1932), pp. 617-20.
[104] Galison, *Image and Logic,* (1997), p. 151.
[105] A few months earlier, in February 1932, Chadwick had just discovered the neutron (Chadwick, "Possible Existence of a Neutron," (1932), p. 312).
[106] Blau, curriculum vitae, GDSCA, (in English)
[107] Blau, curriculum vitae, GDSCA, (in English). In a self-description written later (1963) than this one (1941), Blau mentions that she received the fellowship in 1933. (Blau, curriculum vitae, Leopold Halpern Papers) From letters to Meyer it becomes obvious that the earlier date is correct. See for example, Blau to Meyer, October 4, 1932, AÖAW; Blau to Meyer, December 12, 1932, AÖAW. On Blau's time in Göttigen see Bischof, *Frauen am Wiener Institut,* (2000), pp. 75-76.
[108] Kirsch and Wambacher, "Uber die Geschwindigkeit," (1933), pp. 241-249.

7.5. Crossing Boundaries: From Radioactivity to Oceanography and From Vienna to Bornö

Over the years, since Pettersson's first visit to Vienna, he and his family kept moving back and forth from Vienna to Götteborg, resembling nomadic travelers. In the beginning Pettersson spent the academic years in Sweden teaching at the Göteborgs Högskola, a *Kommissionen* lectureship position in oceanography, and during springs he moved to Vienna to work with his colleagues at the Radium Institute. The fellowship from the International Educational Board offered him the luxury to stay in Vienna most of the year, spending only the summers in Sweden. The year 1927 was decisive for his further career. The end of the financial support from the International Education Board along with the repercussions of Chadwick's visit in Vienna, forced Pettersson to look for an alternative solution. That autumn Svante Arrhenius, professor of physics at the University of Stockholm died, leaving his position vacant.[109] To Pettersson that was a chance to finally obtain a professorship, to regain his authority, and continue research on radioactivity. Although in the Radium Institute he was the leader of the group working on artificial disintegration, other than this, he was simply a lecturer in a made-up position through his father's connections.[110] In 1928 Pettersson applied for Arrhenius' vacant position but his application met the tenacious opposition of Manne Siegbahn from the appointment committee. Caught in the academic politics of Sweden, Pettersson lost the battle, despite the supportive letters that Meyer solicited from Hevesy, Fajans, and Marie Curie.[111] To the eyes of the scientific community the controversy was still unresolved, yet the contradiction of Pettersson's research with the work done in Cambridge and in Berlin by Bothe and Fränz was enough of excuse for his opponents in Sweden.[112]

[109] Hughes, *The Radioactivists,* (1993), p. 158. Meyer to Hevesy, October 30, 1928, AÖAW; Meyer to Curie, October 30, 1928, AÖAW; Meyer to Fajans, November 5, 1928, AÖAW. As Curie and Hevesy mentioned in their letters to Meyer, they were willing to support Pettersson since the controversy between his group and Rutherford was not resolved (Curie to Meyer, November 9, 1928, AÖAW; Hevesy to Meyer, November 3, 1928, AÖAW).

[110] In 1914 Gustaf Ekman offered the funds for Pettersson's position after his father's intervention (Svansson, interview by the author, September 21, 2001, Göteborg. See also Deacon, "Hans Pettersson" (1966), pp.405-421; Pettersson, "Recent Oceanographic Research" (1933), pp. 207-218).

[111] Hughes, *The Radioactivists,* (1993), p. 158.

[112] Gütachten von Siegbahn, Meyer Nachlass, AÖAW.

The spring of 1928 Pettersson returned to Vienna once more with his family.[113] This time he had with him a few red clay samples from sea bottom sediments, which he wanted to analyze for their radium content. Rona was assigned the job. As she soon found out, "the contamination of the Radium Institute was too high to permit small amounts of radium to be determined. The needed equipment was moved to the oceanographic station in Bornö, on Gullmarfjord, in south Sweden. Here I spent many summer months, staying sometimes well into the fall."[114] By Pettersson's choice, laboratory technologies traveled across disciplinary lines from radioactivity to oceanography and geographically moved from Vienna to Bornö, at the summer cottage of Pettersson's family and his father's oceanographic station. Shortly after, carrying with them their portable apparatuses, most of the women who previously worked with Pettersson in Vienna crossed the boundary of their discipline, analyzing sea bottom samples for their radium content in Bornö. Once again radium functioned as the boundary object shared between physics and oceanography, enabling the women of the Institute to extend and alter the boundaries of radioactivity. Unable to get serious funding for their work on artificial disintegration, Rona, Blau, and Karlik visited Bornö during the summers for almost the next decade. Having fewer choices than their male colleagues, unstable positions in Vienna, and flexible personal lives as single women, the road to Bornö became a summer vacation ideally combined with serious research. Strangely enough, all of them experienced an odd feeling of stability when in 1930, Pettersson obtained a professorship in Göteborg. With his father's intervention, the wealthy Swedish Knut Mark, offered funds for a new chair in oceanography at the Göteborg Högskola.[115] "This meant," as Pettersson's daughter put it, "that my parents for the first time in their family life could afford a place of their own to live. Until then they had 'lived in' with my maternal grandparents during winter times."[116] To Pettersson, the new position offered a sense of professional recognition and eased his personal life. Yet to his women collaborators it meant a paradoxical opportunity for professional stability in temporary occupation.

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113 Pettersson to Mellbye, April 15, 1928, (in Swedish, Agnes Rodhe Papers, translated by Rodhe); Almanach, Akademie der Wissenscahften in Wien, (1929), p. 201. AÖAW.
114 Rona, *How it Came About,* (1978), p. 60.
115 Svansson, interview by the author, September 21, 2001, Göteborg.
116 Rodhe to Rentetzi, October 29, 2001.

With his unique talent to enlist patrons and donors, Pettersson financed his oceanographic research, secured funds for the women of the Radium Institute, and purchased the necessary apparatus for his new endeavor. Besides turning the Bornö station into a state-owned permanent center for hydrographic research, he persuaded Alice and Knut Wallenberg, Swedish industrialists, to donate money for new facilities. Adding central heating, sanitary installations, electric light, and new equipment, Pettersson made the space of the Institute available for research during the whole year for different working groups.[117] Set at the intersection of oceanography and radioactivity, and encompassing research from biology to hydrology and metrology, the Bornö station was developed into Pettersson's main research institute. As Rona reported to Meyer in 1935, "this is an ideal institute for work."[118] She was probably right. Situated in close proximity to Oslo and Copenhagen, the oceanographic institute in Bornö placed women in a convenient environment for research, scientific visits to Gleditsch's and Bohr's institutes, and social entertainment in the Swedish Kalhuvudet, an island north of Göteborg where Pettersson's grandparents once maintained an old herring factory. Now a summer cottage, the house in Kalhuvudet regularly hosted Karlik, Rona, and occasionally Blau, who all became close friends with the family.[119] When, for example, Rona worked in Bornö the summer of 1935, besides visiting Gleditsch in Oslo, she met with her old colleague Hevesy in Copenhagen, who at the time was in Bohr's institute. In Kalhuvudet, she spent time with Karlik and the Petterssons.[120] The summer before, Karlik paid a visit to Copenhagen as well, where she had the chance to discuss their earlier work on artificial disintegration with Bohr's team.[121] In 1935, while Blau deputized Karlik as *wissenschaftliche Hilfskraft* at the Radium Institute, the latter had the chance to spend a longer period at the oceanographic station in Sweden.[122]

Although this proved to be important during the difficult years of their political persecution by the Nazis after 1938, to become a part of the network of scientists working on radioactivity and nuclear physics was not the only benefit for the women of the Institute. Working on the border zone of oceanography and physics,

[117] Pettersson, "Recent Oceanographic Research," (1933), pp. 207-218. I owe my thanks to Artur Svansson for pointing out this article to me.
[118] Rona to Meyer, September 9, 1935, AÖAW. See also Rona, *How it Came About*, (1978), p. 63.
[119] Rodhe interview by the author, September 22, 2001, Göteborg,.
[120] Rona to Meyer, September 9, 1935, AÖAW.
[121] Pettersson to Karlik, September 27, 1934, GUA.
[122] Meyer, June 22, 1935, Karlik's file, Mitarbeiter/Assistenten, AÖAW

the opportunity for research was in the center of their concern. After Rona analyzed the first ocean sediments, she found out that the radium content was high and undermined previous results that saw a connection between the radium content and water depth.[123] To resolve the discrepancy Rona and Pettersson embarked on a wider project, intending to perform exact measurements of the concentration of radioactive elements in seawater. It was then that Karlik, Föyn, Rona, and Pettersson formed a group on seawater research, joined from time to time by Gleditsch.[124] They started by analyzing the radium content of seawater taken from Gullmarfjiord and the more open Swedish sea of Skagerak. During the following years, Rona and Karlik spent part of their summers in Bornö analyzing sediments. During the winters in Vienna, they kept up their collaboration with Pettersson, who often sent sealed bottles of seawater for analysis to the Radium Institute.[125] Pettersson's wife Dagmar "did jobs when needed"[126] and helped him regularly in his experiments.[127] As their daughter recalls, "she used to do much of the routine titration on the innumerable samples of sea water coming e.g. from the Bornö Station. Simple but accurate work, she liked it and got paid. I remember her doing it, measuring the NaCl content by adding certain amounts of $AgNO_3$ with a drop of a color agent signaling neutrality."[128]

On the border zone of oceanography and radioactivity, Karlik and Friedrich Hernegger, a research student at the Radium Institute, brought up concerns on biological issues in relation to the uranium content of seawater. "It appears not unlikely that an accumulation of uranium in the tissue of marine organisms may occur which again may possibly account for some interesting results obtained concerning the high radioactivity of the waters in the petroleum districts in Russia."[129] Working in Przibram's research group, Hernegger had already developed an optical method for detecting and measuring small quantities of uranium based on the fluorescence phenomenon.[130] Owing to uranium's weak radioactivity, previously employed electrometric methods were not satisfactorily accurate. In 1933, with the support of a

[123] Rona referred to the research done by James Joly, which is presented in his book *Radioactivity and Geology* (Rona, *How it Came About* (1978), p. 63).
[124] Rona, *How it Came About*, (1978), p. 64.
[125] See for example Pettersson to Rona, February 24, 1934, AÖAW. Pettersson sent Rona two bottles of seawater in Vienna. See also Hernegger and Karlik, "Uranium in Sea-Water," (1935), p. 5.
[126] Rodhe to Rentetzi, October 29, 2001.
[127] Pettersson to Karlik, September 27, 1934, GUA; Pettersson to Karlik, December 27, 1934, GUA.
[128] Rodhe to Rentetzi, October 29, 2001.
[129] Hernegger and Karlik, "Uranium in Sea-Water," (1935), p. 4. See also Herneggen and Karlik, "Die quantitative Bestimmung," (1935), pp. 135-140.
[130] Hernegger, "Methoden für einen empfindlichen Urannachweis," (1933).

grant from the Rockefeller Foundation, Karlik and Hernegger acquired a glass spectrograph of high light-gathering power.[131] Expert in spectroscopic measurements due to her earlier work with Przibram and Herbert Haberlandt, Karlik joined by Hernegger, photographed the characteristic band-spectra due to uranium fluorescence and then compared those with spectra of known uranium content.[132] Supported by a stipendium from the Austrian ministry of education, Karlik performed the first experiments in Bornö in the summer of 1935 and she moved some samples to Vienna the following fall.[133] The whole investigation became possible through the support and encouragement of both Meyer and Pettersson. As Karlik and Hernegger stressed in their article, they were hoping to enlarge their research project "through a continued collaboration between the Institut für Radiumforschung and the Oceanografiska Institutet of Göteborgs Högskola."[134] Apparently, as their publications reveal, Rona, Karlik, and Pettersson continued their research on the intersection of radiochemistry and oceanography throughout the 1930s.[135] At the same time, by and large, they remained on the margins of the research on nuclear physics.

7.6. From Radioactivity to Nuclear Physics

The transformation of the experimental culture in both the Cambridge and Vienna laboratories was only the tip of an iceberg that indicated a deeper transformation in the material culture of physics and its theories during the 1930s. Granting the possibility of partial autonomy to instrumentation, experimentation, and theory, Galison argues that quasi-autonomous traditions carry their own

[131] Hernegger and Karlik, "Uranium in Sea-Water," (1935), p. 5.
[132] Haberlandt, Karlik, and Przibram, "Synthese der blauen," (1933), p. 235; Haberlandt, Karlik, and Przibram, "Synthese der grünen," (1934), p. 2; Haberlandt, Karlik, and Przibram, "Zur Fluoreszenz des Flurites II," (1934), pp. 151-161; Haberlandt, Karlik, and Przibram "Zur Fluoreszenz der Flurites III," (1935), pp. 77-83; Haberlandt, Karlik and Przibram, "Zur fluoreszenz der Flurites IV," (1935), pp. 135-140; Haberlandt, Karlik, and Przibram, "Artificial Production," (1934), pp. 99-100. On the work of this group see Przibram, "1920 bis 1938," (1950), pp. 32-33. Karlik worked with them as expert in spectroscopic analyses.
[133] Hernegger and Karlik, "Uranium in Sea-Water," (1935), p. 5; Meyer, June 22, 1935, Mitarbeiter/Assistenten, Karlik's file, AÖAW. Bischof, *Frauen am Wiener Institut,* (2000), p. 107.
[134] Hernegger and Karlik, "Uranium in Sea-Water," (1935), p. 6. Indeed, the collaboration between the two institutes proved to be important for scientists in both countries. Besides Karlik, Rona, and occasionally Blau doing research at the Bornö station, one of Pettersson's Swedish colleagues, Börje Kullenberg, visited the Radium Institute in the end of 1938. He was the first assistant of the Svenska Hydrografisk-Biologiska Kommissionen, and he appeared as the Radium Institute's collaborator in the Academy's almanac in 1939 (Almanach der Akademie der Wissenschaften, (1939), p. 192, AÖAW.).
[135] Föyn, Karlik, Pettersson, and Rona "Radioactivity in Sea-Water," (1939), pp. 1-44.

periodization.[136] In the case of radioactivity, although during the 1930s theorists, experimentalists, and instrument makers had “a life of their own,” they often met in the same laboratories and collaborated, altering the boundaries and the focus of their field. As early as 1928 the Russian theoretical physicist George Gamow, a research fellow at Niels Bohr’s laboratory in Copenhagen, applied the new quantum mechanics to the nucleus. [137] He showed that the emission of alpha particles from radioactive sources follows a tunneling process that can be explained by the wave properties of fundamental particles.[138] This explained why the emitted particles had lower energies that classic mechanics and the work of Rutherford and Chadwick could not account for.[139] “On the strength of this work,” as Brown argues, “Gamow became a frequent and valued visitor to the Cavendish.”[140] In 1930 Chadwick, primarily an experimentalist, co-authored a paper with the theoretician Gamow on the artificial disintegration of alpha particles.[141] The next year Gamow’s newly published book on the *Constitution of Atomic Nuclei and Radioactivity*, was devoted to the Cavendish laboratory, making tangible the intersection of theory and experiment in what used to be the field of radioactivity.[142] Envisioning the potential of Gamow’s theoretical work to disintegration by artificially accelerated particles, John Cockcroft who had been working at Rutherford’s lab since the early 1920s, put his hands on the instruments of the field. Joined by Ernest Walton, they designed a high-voltage apparatus for producing accelerated protons which were directed to various materials. [143] The emitted particles were recorded in a zinc sulfide screen by means of the old scintillation technique.[144] However, nuclear physics was already the focus and practice of those who worked on radioactive substances throughout the 1920s.

[136] Galison, *Image and Logic,* (1997), p. 799.
[137] Gamow, *My World Line,* (1970); Brown, *The Neutron and the Bomb,* (1997), p. 324.
[138] Pais, *Inward Bound,* (1986); Cockcroft, “Some Recollections,” (1984); Growther, *The Cavendish Laboratory,* (1974), pp. 227-228.
[139] With his letter to *Nature* in November 1928, Gamow addressed the phenomenon of artificial disintegration. He explained why Pettersson’s and Kirsch’s work in Vienna could not be reliable and stressed his agreement with the observations of the Cavendish team (Gamow, “The Quantum Theory of Nuclear Disintegration,” (1928), pp. 805-806; See also Hughes, “‘Modernists with a Vengeance’,” (1998), pp. 339-367).
[140] Brown, *The Neutron and the Bomb,* (1997), p. 95.
[141] Chadwick and Gamow, “The Artificial Disintegration by α-particles,” (1930), pp. 54-5.
[142] Gamow, *The Constitution of Atomic Nuclei and Radioactivity,* (1931); Hughes, *The Radioactivists,* (1993), p. 208.
[143] On the history of early particle accelerators see McMillan, “Early History of Particle Accelerators,” (1979), pp. 113-129; Seidel, “The Origins of the Lawrence Berkley Laboratory,” (1992), pp. 21-45. Pais, *Niels Bohr’s Times,* (1991), pp. 374-379.
[144] On the work of Cockcroft and Walton see Growther, *The Cavendish Laboratory,* (1974), pp. 227-228; Cockcroft, “Some Recollections,” (1984), pp. 74-80;

Theory, experiment, and instrumentation fed one another while each reserved its partial autonomy and its scope of research.

In 1932, the discovery of the neutron by Chadwick, based on the work done at the Cavendish, was certainly benefited by the radiochemical work of Irene Curie and Frederic Joliot in their Institute in Paris. Their paper on the penetrating radiation from beryllium that appeared in the *Comtes Rendus* gave Chadwick the answers he needed.[145] As Ernest Lawrence from the University of California at Berkley admitted, "the pioneer work of Rutherford and his school clearly indicated that the next great frontier for the experimental physicist was surely the atomic nucleus."[146] Somewhat sadly, Blau reported to Meyer from Göttingen that "for the photographic method probably there is no time left, since all should be in the service of neutrons."[147] At the 1933 Solvay conference in Brussels, devoted to the atomic nucleus, all but the Viennese attended the meeting.[148] Shortly thereafter, in 1934, the couple Joliot-Curie discovered artificial radioactivity.[149] Their Nobel Prize in chemistry in 1935 gave them the power to control "every piece of nuclear work in France," [150] and added to the prestige of the Institut du Radium in the international scientific scene. For Enrico Fermi, the Italian physicist working in Rome, that "was a golden opportunity."[151] His idea was to produce effects like those recorded in Paris using neutrons instead of alpha particles. While the Italian group, formed by Emilio Segre, Edoardo Amaldi, Franco Rasetti and Oscar D'Agostino exploited the slow neutrons, in Berlin Meitner was working jointly with Hahn at the Kaiser Wilhelm Institute for Chemistry. As Meitner later described, "from 1934 to 1938, Hahn and I were able to resume our joint work, the impetus for which had come from Fermi's results in bombarding heavy

[145] Brown, *The Neutron and The Bomb,* (1997), pp. 103. The Joliot-Curies' paper helped Chadwick to put into context a phenomenon described by Walter Bothe and Hans Becker, who worked in Berlin. They discovered that when beryllium was bombarded by alpha particles, a low intensity radiation was emitted that could penetrate a thick surface of lead. See also Crossfield, "Irene Joliot-Curie," (1997), p. 112; Trenn, *Transmutation Natural and Artificial,* (1981), p. 75.
[146] Lawrence, "The Evolution of the Cyclotron," (1965), pp. 425-43.
[147] Blau to Meyer, February 18, 1933, AÖAW, (translation mine)
[148] See the names at the photo, picturing the participants of the conference in Brown, *The Neutron and The Bomb,* (1997).
[149] Crossfield, "Irene Joliot-Curie," (1997), pp. 97-123.
[150] Crossfield, "Irene Joliot-Curie," (1997), p. 115.
[151] Segre, "Nuclear Physics in Rome," (1977), p. 51.

elements with neutrons. This work finally led Otto Hahn and Fritz Strassmann to the discovery of uranium fission."[152]

Described as the "happy thirties" for physics,[153] and as a transition from atomic to nuclear physics,[154] the 1930s combined apparently fruitful research in physics with, however, an increasing political horror in Europe. Hitler's rise in power in 1933 was decisive in disrupting the lives and research of many scientists, mainly Jewish, in Germany and eventually in Europe as a whole, long before the Second World War. While still at the physics institute in Göttingen, Blau mentioned in her regular correspondence to Meyer that "on the political circumstances one realizes here absolutely nothing, since, in principle, one should not talk about politics in the Institute."[155] Perhaps in Pohl's institute scientists avoided facing Hitler's reality. Yet in Austria the transition from Red Vienna to *Austrofascismus* and consequently to the *Anschluss* was hard to dismiss.

7.7. The Laboratory as a System of Labor

Let us pause for a moment and look briefly at what Pettersson's departure from Vienna meant for the Radium Institute and its personnel. First of all, the loss of the key figure of the group led in disarray the study of atomic disintegration, which additionally suffered from a severe financial crisis already going on. Most deeply affected were the women of the team, given the fact that they lacked stable university positions and monthly payments from the state. As soon as the flow of grant money and generous donations ended, the women financed from these sources faced professional and financial instability. It was probably this insecurity that prompted most of them to look for stipendiums and fellowships in other institutes. Kara-Michailova and Karlik went to England and, although the latter returned to the Institute in a year, the former never did. Blau visited Göttigen and Paris on a yearly fellowship and Rona followed her in Paris in 1934 for a few months.

As most of the women who were actively engaged in radioactivity research remained single, their personal lives were flexible and it was easy for them to travel.

[152] Meitner, "Looking Back," (1964), p. 7. On nuclear fission see Sime, *Lise Meitner,* (1996); Stuewer, "The Origin of the Liquid-Drop Model," (1994), pp.76-129; Frisch, "Experimental Work with Nuclei," (1979), pp. 65-75.
[153] Bethe, "The Happy Thirties," (1979), pp. 11-25
[154] Goldhaber, "The Nuclear Photoelectric Effect," (1979), pp. 83-106.

Undermining the stereotype of their "devotion" to science, I want to argue that these women lived through a transitional period. Meanings of sexual difference, of what a man and a woman signified, were in flux. The social democratic politics of Red Vienna that coincided with the time of Pettersson's research at the Institute offered a new conceptual framework for addressing issues of gender identities. Caught in the drastic shift from traditional values to those that envisioned women and men as socially, scientifically, and politically active, the women scientists faced the dilemma of "either/or" concerning scientific career and personal life. Such being the case, when Pettersson left the Institute his women collaborators scattered in other European Institutes, obtaining yearly fellowships and small stipendiums. The official academic politics outside of the Radium Institute kept them away from university positions and limited their career advancements. Instead of viewing this discrimination in terms of exclusion and victimization, I argue that women took their lives and careers in their hands and, forced by the circumstances, they altered the boundaries of their discipline. From radioactivity to oceanography and from Vienna to Bornö, Karlik, Rona, and occasionally Blau, crossed the disciplinary lines of radioactivity, introducing research problems from biology and oceanography. By doing so, they were able to acquire grant money, widen their professional network, and remain scientifically active and innovative in a world in flux.

Second, the private resolution of the controversy did not directly affect the credibility of the Vienna researchers. Although the Cambridge group kept Pettersson and his colleagues away from the scientific meetings they were able to control, especially the women of the Institute eventually gained status within the scientific community. The lengthy exchange of publications between Cambridge and Vienna in prestigious and international journals attracted the attention of other institutes and scientists. For example, in 1927 Meyer received a request from Walter Clark, a physicist who worked on the theory of photographic sensitivity, to send him Blau's reprints.[156] Also, when Blau visited Pohl's institute in Göttigen, she did so as a representative of her Institute. In one of the first colloquiums that she attented, Pohl asked her to present her work and to decribe the research projects at the Radium Institute in Vienna.[157] A tour in the Agfa industry in Leipzig, a visit to the physics

[155] Blau to Meyer, February 2, 1933, AÖAW, (translation mine).
[156] Clark to Meyer, December 2, 1927, AÖAW.
[157] Blau to Meyer, December 12, 1933, AÖAW.

institute in Brussels, and an invitation to the Cavendish laboratory by Chadwick, were all possible because Blau's research obtained weight through her participation in the Cambridge-Vienna controversy.[158] Similarly, Rona's second visit to Paris in 1934 took place mainly because her work on polonium during the 1920s proved to be central for the investigations in Vienna. In 1934 Karlik was invited to give a talk in Copenhagen at Bohr's Institute. "I must say," commented Pettersson, "you have a rare gift in seizing opportunities."[159] Apparently, all of these women did seize the opportunities that their work on artificial disintegration offered them.

Last, with Pettersson's departure the parts of the scintillation counter and the rest of the apparatus that he purchased with the funds from Sweden and the Rockefeller grant were left behind. Those constituted the Institute's only chance to enter the world of nuclear physics. Later on, in the political upheavals of 1938, they became the most desired object between the scientists in exile and those in power.[160] The scintillation counter, nevertheless, was not able to survive in the new material culture that nuclear physics imposed on the physicists' research. The passage from radioactivity to nuclear physics placed the laboratory technologies of the first into the drawers of the Cambridge laboratory and on the working benches only of those who were financially struggling to survive the changes.

As I argued in this chapter, besides being a preeminent site for producing scientific knowledge, the Radium Institute in Vienna, as every other laboratory, was clearly a system of labor. The study of the laboratory, and in extension science, as a labor system and as a system of knowledge, draws two distinct pictures of what was going on within the laboratory walls.[161] Women and men working in the Institute were not merely scientists who performed their research under the exact same conditions. They were subjected to a system of labor partly co-defined by the director of the Institute and its personnel and partly imposed by the Austrian ministry of education. And that system was deeply gendered in that university careers were not equally open to women as they were to men. However, for reasons that I exposed in the previous chapters, in contrast to the Cambridge group, experimentation in Vienna

[158] Blau to Meyer, October 4, 1932, AÖAW. On a letter to Meyer, Blau reported that she had an invitation by Chadwick to visit the Cavendish for a few days during the summer of 1933 (Blau to Meyer, June 29, 1933, AÖAW).
[159] Pettersson to Karlik, September 9, 1934, GUA.
[160] See Karlik to Pettersson, May 1, 1938, GUA.
[161] I owe my thanks to Eva Kranakis for pointing out this important aspect in my work at the SHOT meeting in Toronto, in 2002.

and the skills that surrounded the scientific work were not gendered. Women, despite their stereotypical depictions, were not technicians and patient assistants to their male colleagues. They had the same type of control over their experiments, instruments, and theories of their discipline as the men of their research group did. The history of the Radium Institute is part history of the laboratory as a system of knowledge and part epistemology. Certainly, it is part history of the laboratory as a system of labor and part sociology as well.

CHAPTER 8
THE DECLINE OF THE *MEDIZINER-VIERTEL*

Behind a façade of legality, Hitler seized absolute power in March 1933 and put an end to parliamentary democracy in Germany. His first and main concern was to purge Jews from public life, at which he immediately succeeded by the "Law for the Restoration of the Professional Civil Service." Non-Aryans were excluded from government and civil service positions including the universities. Numerous historical studies have tackled the consequences of the rise of National Socialism for German academic life, ranging from institutional and disciplinary histories to scientific biographies and comparative studies.[1] The persecution of Jews and the gender discriminatory politics of the Third Reich were, nevertheless, an acute indication of the rise of nationalist and fascist movements in Europe.[2] In Austria, the political Catholicism and fascism preceded the National Socialist ideology but, as Friedrich Stadler points out, the transition was a seamless one.[3] In 1933, the chancellor Engelbert Dollfuss managed to suspend the power of parliament, leading the country to a civil war in February 1934. The defeat of the labor movement was absolute and sealed with the ban of the SDAP, the end of Red Vienna, and the political annihilation of the social democratic forces. The immediate concern of Kurt von Schuschnigg, Dollfuss' successor in power, and his fascist regime was to purge the civil services this time of the Social Democrats. It is not by chance that the period of cultural emigration out of Red Vienna the first years after February 1934 was characterized by the emigration of the political left.[4] Prominent in the Social Democratic Party, in the sciences and the arts, as well as in industry and high finances were Viennese Jews. Thus, the political persecution of the Social Democrats was simultaneously

[1] For examples of institutional and disciplinary histories see Beyerchen, *Scientists Under Hitler,* (1977); Deichmann, *Biologists under Hitler,* (1992); Macrakis, *Surviving the Swastika,* (1993); Hoffman, "Die Physikdenkschriften," (1989), pp. 185-211. For scientific biographies see Sime, *Lise Meitner,* (1996); Cassidy, *Uncertainty: The Life and Science of Werner Heissenberg,* (1992). For comparative studies see Walker and Sachse (eds), *Kaiser Wilhelm Society in Third Reich,* (forthcoming). For a general overview of science and technology under NS see Renneberg and Walker (eds), *Science, Technology and National Socialism,* (1994).

[2] On gender and racial discriminatory politics see for example Gellately and Stoltzfus (eds), *Social Outsiders in Nazi Germany,* (2001). On the understanding of the rise of Austro-fascism and National Socialism see Fellner, "The Background of Austrian Fascism," (1971), pp. 15-43.

[3] Stadler, F. "The Emigration and Exile," (1995), p. 14.

[4] Stadler, F. "The Emigration and Exile," (1995), p. 17.

accompanied by anti-Semitic hate campaigns and attempts to eliminate the 'Jewish' left.

Clearly, the target was the democratic political reforms that took place in Red Vienna. The *Mediziner-Viertel* mirrored the dark part of the authoritarian ideology of the new regime and reflected the abrupt destruction of the socialist politics in the Viennese education and academy. In chapter five I argued that in Red Vienna interdisciplinary collaborations and scientific exchanges flourished and were widely supported by the key figures of the SDAP. It was also the time that a specific gender discourse provided the framework for a large number of women to envision themselves as active members of the Viennese scientific society. In this chapter I want to trace the abrupt decline of the *Mediziner-Viertel* that was brought about by the forced elimination of the Social Democrats who held sway in the heady of Red Vienna. For instance, I see the thwarting of a promising project, that of the establishment of a joint radium laboratory between the Radium Institute and the *Vivarium,* as a symptom of the decline of Red Vienna and the advent of fascist politics.

Focusing on the Radium Institute, my interest here is on what was specifically fascist or nazi in the scientific practice. How did patterns of life within the Institute change after 1933? What did it mean to be a woman experimenter, and particularly Jewish, working at the Radium Institute? With an emphasis on those women who, during the 1920s, in collaboration with their male colleagues, boosted the Institute to the forefront of research on artificial disintegration, I follow their trajectories from 1933 to 1938. After the *Anschluss,* Jewish men and women were forced into exile, underling the fact that gender and race discriminations were so complexly intertwined that no single perspective can capture the full story.

Although the historical study of science and technology under the Nazis is an established field of historical research, the Austrian case has been less investigated. As the historian Fritz Fellner argued in 1971, after the collapse of the Third Reich, a fateful decision among the Austrian historians served as a convenient way to escape political and scholarly responsibility. "Pretending that the task of *die Vergangenheit bewältigen* (to cope with one's past) had a special nature and too many political and personal implications, they claimed that the historical interpretation of the most recent past was too complicated in method and scope to be included in regular historical research."[5] Thus, the history of the interwar years and that of National Socialism formed a separate category known as *Zeitgeschichte* and it was left mainly to foreign historians and journalists.[6] The symposium on emigration and exile of Austrian scientists organized in Vienna in 1987 placed the issue in larger historical context, opened up interesting questions, and fostered future research projects. In focus was the phenomenon of the emigration of Austrian scientists from various schools and disciplines, bringing often a feminist perspective to the discussion.[7] In this chapter I focus on those years, from 1933 to 1938, examining the degree to which the new political and social order affected the scientific community and the Radium Institute, seeking not to judge morally but to enlarge the picture of what took place during that period.

8. 1. From *Austrofascismus* to the *Anschluss*

Apparently the evidence of scintillation counting, relying upon the individual observer and his or her experience, was not the only uncertainty that the Viennese experimenters faced during Chadwick's visit in 1927. In the city elections on April 2 of that year, the Austrian Social Democrats experienced their greatest electoral victory of the interwar years. As Rabinbach points out, "Its [SDAP's] electoral gains were illusory as long as it controlled neither the legal structure of the state nor the instruments of power."[8] Three months later, on July 15, the police violently stamped out a massive demonstration led by socialist workers, leaving eighty-five dead and hundreds injured.[9] The event marked the beginning of the SDAP's decline and the uprising of the fascist and nazi ideologies. In 1931, in the context of the world's economic crisis, the crash of the *Creditanstalt,* the prominent Vienna bank that financed much of Austria's industry, mobilized a wider economic and political crisis in the country.[10]

[5] Fellner, F. "The Background of Austrian Fascism," (1971), p. 16.
[6] On the same discussion see Stadler, F. "The Emigration and Exile," (1995), pp. 14-26; Fellner, G. "The Emigration of Austrian Historians," (1995), pp. 174-186.
[7] The symposium was organized by the Ludwig Boltzmann Institute for the History of Scientific Societies, and the Institute for Science and Art with the support of the ministry of education, art, and sport, as well as the ministry of science and research. The papers were published in two well-documented volumes and edited in 1987 and 1988 respectively by Friedrich Stadler (Stadler, *Vertriebene Vernuft I* and *II*, (1987), (1988)).
[8] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 33.
[9] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 33.
[10] Stadler K., *Austria,* (1971), p. 123; Barker, *Austria 1918-1972*, (1973), p. 68-70.

In May 1932 Austria underwent parliamentary restructuring once more. The coalition between the Christian Socialists and the Pan-German People's party was dissolved and the new chancellor, Dollfuss, fellow of the Christian Socialists, turned towards the Social Democrats, offering them a coalition with his party. When the Democrats responded negatively, Dollfuss made a deal with the *Heimwehr*, an anti-republican paramilitary organization supported by big business and Catholic political leaders.[11] Already in the city elections a month earlier, National Socialists emerged as a serious political force and a threat for the conservative Christian Socialists, who held a fragile majority in the parliament.

Eventually, faced with a still strong Social Democratic Party on the left and an emerging Nazi regime on the right, Dollfuss and the other Christian Socialists suspended the Austrian parliament in March 1933. Seizing the opportunity, the Nazis committed a number of serious terror acts, mainly in Vienna but also in the rest of the country. That gave Dollfuss the chance to ban their party. Although illegal, the Nazis continued to exist without very much difficulty.[12] With Mussolini as his ally and protector, Dollfuss fought on two fronts, against the Nazis and, more fiercely, against the Social Democrats. All newspapers and primarily the *Arbeiter-Zeitung*, the social democratic paper, were placed under strict government censorship. Part of Dollfuss' anti-democratic politics was to drastically reduce the budget of the city of Vienna and cancel all the social reform programs that were put forward by the Social Democrats.[13] In the following months, in the context of the wider European political crisis and Hitler's rise to power in Germany, the political situation in Vienna was increasingly unstable. The SDAP was the main concern of the new fascist regime. Under Mussolini's pressure, Dollfuss proclaimed not only the end of the liberal state and the constitution of the Austrian fascist *Ständestaat*, but he tried to extinguish any opposition from the Social Democratic camp.

The obituary of Red Vienna was finally written on the streets of the city just a few days after the arrest of the mayor, Karl Seitz. For three days, from February 12 to 14, 1934, frustrated armed workers fought with government troops in an already lost fight between socialism and Dollfuss' fascist regime. Although the Social Democrats were defeated, and the dissolution of all parties was a fact, the Nazis were franticly

[11] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 81. On the Heimwehr see Gruber, *Red Vienna,* (1991), p. 201.
[12] Barker, *Austria 1918-1972*, (1973), p. 74.

planning Dollfuss's assassination. With Hitler's approval, the Nazis attacked the Chancellery in Vienna and killed Dollfuss.[14] In July of the same year another Christian Social, Kurt von Schuschnigg, came into power. For the next two years Austria remained independent in the midst of a serious political crisis. In 1936, as his own solution to the uprising problems, Schuschnigg signed an agreement with Hitler giving amnesty to imprisoned Nazis and including several others in the government.[15] It was these acts and the undermining of the Austrian democracy that paved the way for the German invasion in 1938. The Austrian-German reconciliation promoted Hitler's plans for Austria's annexation to Germany, which finally took place on March 12, 1938, when German troops marched into Vienna.[16]

8.2. Dismantling the *Mediziner-Viertel*

In the ideological context of German-nationalism and political Catholicism, Jewish and Social Democrats were among the first targets of both the fascist and nazi regimes. The anti-democratic tensions that surrounded politics were immediately reflected in Vienna's scientific community. The excellent collection of articles put together by Friedrich Stadler and Peter Weibel on *The Cultural Exodus from Austria* draws a vivid picture of the decline of the *Mediziner-Viertel*.[17] Even before Hitler's arrival on the Austrian scene, the destruction of Viennese culture and science, centered at the University and its institutes, started with the Austrofascists. The *in vivo* cultural and epistemic laboratory, circumscribed by Währingerstrasse and Alserstrasse, was brutally eradicated by anti-Semitic and anti-democratic attacks.

From early on the fascists controlled teaching appointments at the University of Vienna and at the same time, Nazi students distributed "black lists" of Jewish and socialist professors demanding restrictions and dismissals.[18] The purge of educational institutions started from the Ernst Mach Society, which was dissolved soon after the

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[13] Rabinbach, *The Crisis of Austrian Socialism,* (1983), p. 156.
[14] Brook-Shepherd, *Dollfuss,* (1978).
[15] Stadler K., "Austria," (1969), p. 109.
[16] On Sunday March 13, 1938, New York Times reported that German's entered Austria a day before and Hitler gave a speech at Linz where he proclaimed the *Anschluss.* ("Hitler Enters Austria" *New York Times,* March 13, 1938. p.1). On the Austrian history of this period see Rabinbach, *The Crisis of Austrian Socialism*, (1983); Stadler K., *Austria,* (1971); Kindermann, *Hitler's Defeat in Austria,* (1988); Brook-Schepher, *Dollfuss,* (1978).
[17] Stadler and Weibel, *The Cultural Exodus from Austria,* (1995). See also Stadler, *Vertrieben Vernunft I* and *II*, (1987) and (1988).
[18] Stadler, F. "The Emigration and Exile of Austrian Intellectuals," (1995), p. 15.

February events on the accusation that the Society disseminated Social Democratic propaganda. In April 1934 Otto Neurath's Social and Economic Museum in Vienna was closed down and replaced by a new institute for Austrian picture statistics headed by the *Heimwher*.[19] The murder of Moritz Schlick, constitutive member of the Vienna Circle, and its public justification by the press in 1936, as Stadler points out, did not come as a surprise.[20] By 1938 most of the Vienna Circle associates were forced to emigrate.[21] Also the threat to the Psychoanalytic Society became apparent with the fascist and nazi propaganda in which psychoanalysis was targeted as 'Jewish' science.[22] Out of the fifty official members of the society, forty-seven were forced to flee Austria.[23] The fate of the psychologists and their institute was similar and even harder. As Bernhard Handlbauer describes, the dissolution of the SDAP disrupted the work of the Viennese psychologists, most of whom were deeply involved in the educational reforms of Red Vienna.[24] Handlbauer's argument is supported by the fact that the majority of Viennese psychologists were Jewish, liberals, and many women among them.[25] One of the first to be harassed by the fascist regime was the Jewish psychologist Marie Jahoda, who after her imprisonment for nine months fled Austria in 1936.[26] Last, of those science institutes that during Red Vienna hosted a remarkable number of women, the *Vivarium* was banned and destroyed after the Nazis seizure of power in 1938.[27]

A similar dark picture can be seen when one considers the gender and racial politics of the fascist regime in reference to women. As the statistics indicate, the number of women students at the University of Vienna dropped sharply after the civil war. In 1933/34, 1761 Austrian women were enrolled at the philosophical faculty, 690 at the medical and 279 at the faculty of law. By 1938/39, the numbers had dropped to 768 in philosophy, 387 in medicine and, most remarkably, in the faculty of law, where only 72 women were enrolled as students.[28] More specifically, during the academic

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[19] Cartwright et all, *Otto Neurath,* (1996), p. 83.
[20] Stadler, F. "The Vienna Circle and the University of Vienna," (1995), pp. 44-55.
[21] Dahms, "The Emigration of the Vienna Circle," (1995), pp. 57-79; Feigl, "The Wiener Kreis in America," (1968), pp. 630-673.
[22] Mühlleitner and Reichmayr, "The Exodus of Psychoanalysis from Vienna," (1995), p. 99.
[23] Stadler, F. "The Emigration and Exile of Austrian Intellectuals," (1995), p. 20.
[24] Handlbauer, "The Emigration of the Viennese Individual Psychologists," (1995), pp. 122-126.
[25] Gardner and Stevens, *Red Vienna and the Golden Age of Psychology*, (1992), p. 80.
[26] Gardner and Stevens, *Red Vienna and the Golden Age of Psychology*, (1992), p. 160.
[27] Reiter, "Zerstört und vergessen," (1999), pp. 585-614.
[28]. We should notice, nonetheless, that the number of men enrolled in the University of Vienna also dropped drastically from 1933/34 to 1938/39. Although in 1933/34 there were 8801 men enrolled, by

year 1933/34, women students in the field of physics accounted for the 18.1 percent of those in the faculty of philosophy. By 1938/39, the percentage had dropped to 12.5.[29] Although at the turn of the century when the University of Vienna opened up its doors to women, Jewish women entered in disproportionately large numbers, by the academic year 1933/34 they represented only 2.8% of those enrolled. By 1938/39 there were none.[30]

The discriminatory gender politics of the Christian Socialists and their anti-Semitism did not come as a surprise in 1933. During Red Vienna any Social Democratic attempt to alter the gender politics concerning issues of abortion, birth control, or sexuality faced the tenacious and even violent resistance of the Christian Socialists.[31] At the same time the anti-Semitism of the Christian Socialists was clearly stated even in their party's program. According to Gruber, "that the SDAP allowed such gutter politics to go unchallenged from the beginning of the republic to its end, with the prominent Jews in its leadership keeping a low profile, weakened the party and undercut the republic as well."[32] Overall, the ideological mechanism of the political Catholicism of the Christian Socialists and the anti-Semitism of the National Socialists absolutely destroyed the social reforms in education and especially in the academy that socialists such as Otto Glöckel and Julius Tandler put forward in Red Vienna.

8.3. Thwarting a Promising Proposal

The failure in 1932 to establish a joint radium laboratory under the auspice of two liberal institutes in Vienna, that of the *Vivarium* and the Radium Institute, was only the most outward sign of a deeper destruction. Tandler's political power and the reform projects of the municipality were at issue much earlier than the fascist's seizure of power in 1934 and certainly long before the Nazis' arrival in the Viennese

1938/39 their number had dropped to 4081 (Tuma, "Die österreichischen Studentunnen," (1993), p. 85.)

[29] Tuma, "Die österreichischen Studentunnen," (1993), p. 88.

[30] Heindl, "Die konfessionellen" (1993), pp. 139-149; Freidenreich, "Gender, Identity, and Community" (1998), p. 154.

[31] For example in 1925 Hugo Bettauer, a democratic novelist who championed on women's rights through his sexual reform magazines, was killed. Bettauer's assassination was the result of a hate campaign of the Christian Socialists and the Chancellor Ignaz Seipel who demanded that the municipal government exercise censorship on Bettauer's writings (Gruber, *Red Vienna,* (1991), p. 165; Stadler F. "The Emigration and Exile," (1995), p. 15.)

[32] Gruber, *Red Vienna,* (1991), p. 27.

scene. When on June 2, 1932, the directors of the *Vivarium* drafted a letter addressing the Austrian Academy of Sciences and presented their joint project with the Radium Institute, it was already too late for any further substantial reforms of the educational and the Vienna welfare system.

The story runs as follows. In June 1932 the founders of the Biological Institute, Hans Przibram and Leopold Portheim, directors of the botanical and zoological departments respectively and of the Institute in general, addressed the *Kuratorium* of the *Vivarium*.[33] The *Kuratorium* was the scientific and administrative supervisory committee, the intermediate between the Institute and the Academy, that among other things handled the Institute's finances.[34] The directors' aim was twofold, exceeding a simple scientific request.

The first stage of the proposal included the establishment of a laboratory devoted to the study of the effects of radium on plants and animals. Of special interest was the investigation of the impact of radium on the sex hormones, a topic not sufficiently researched at the time and one that attracted great interest. Biologists interested in studying the effects of radium on organisms were also invited. The annual amount for the function of the new laboratory was estimated to 36,000 schillings. The project was specifically targeted to the physiological work on the sex hormones of Eugen Steinach, who was proposed to be, according to the plan, responsible for the new laboratory.[35]

Born in a Jewish family in Voralberg, Steinach was the son of a physician. He graduated in 1886 in medicine at the University of Innsbruck and four years later completed his habilitation in physiology at the University of Prague.[36] At the beginning of his career he worked closely with Emil Zuckerkandl, director of the first anatomical institute in Vienna.[37] As Michael Hubenstorf points out, the anatomical institute under Zuckerkandl and Tandler, was populated by Jewish, liberal, socialists, and foreign students.[38] It was probably there that Steinach developed close contacts

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[33] The directors of the Vivarium to the Kuratorium of the Vivarium, June 2, 1932, AÖAW. Wilhelm Figdor and Eugen Steinach were the directors of the physiological and plant departments respectively but not of the whole Institute.
[34] Almanach der Akademie der Wissenschaften in Wien, Biologische Versuchsanstalt, (1914), p. 231, AÖAW.
[35] Steinach performed rejuvenation experiments by stimulating the internal secretion of sex glands. Koestler, *The Case of a Midwife Toad,* (1971), p. 22.
[36] Eugen Steinach, Rigorosentakt, AUW
[37] Reiter, "Zerstört und vergessen" (1999), p. 605.
[38] Hubenstorf, "Anatomical Science in Vienna," (2000), p. 1386.

with Tandler. When Steinach moved to the *Vivarium* in 1912, the transition concerning the cultural and political environment was unnoticeable. Hans Przibram, member of the Viennese liberal bourgeoisie, was acquainted with the architect Adolf Loss and the *Sezession,* where he presented some of his graphics during the winter exhibits of 1899/1900 and 1900/1901.[39] The other two directors, Leopold Portheim and Wilhelm Fidgor, came also from prominent Jewish families with close connections to the industrialists and cultural circles of Vienna.[40] The picture of the *Vivarium* as one of the liberal institutes of the city remains incomplete without mentioning Paul Kammerer, who started his work at the Institute as an assistant in the planning and the layout of the aquaria and terraria.[41] The talented Kammerer studied music at the University of Vienna and was acquainted with the artistic circles of the city, a common interest he shared with Hans Przibram. In 1926 Kammerer took his own life, offering an odd resolution to an ongoing controversy with William Bateson from Cambridge.[42] The Viennese and international presses, bringing the Institute to the center of the scientific attention, covered the episode extensively. Controversially or not, under the auspice of Przibram and Portheim, the work of Steinach, Kammerer, and a number of other prominent researchers boosted the *Vivarium* to the forefront of research in experimental biology. Further, through its connections to the Social Democrats, the *Vivarium* emerged as an important site of the attempted social reforms. During Red Vienna, supporting the municipal projects of educating the public (*Volksbildung*,) Przibram played an instrumental role in reviving an exhibit in the old aquarium of the *Vivarium*.[43] Within the first half year, in 1932/33, the Institute hosted around 6500 visitors and the profit from the tickets reached 2600 schillings.[44] The exhibit was also open to the public schools of the city.

Thus, the initiative to establish a radium laboratory at the *Vivarium* does not come as a surprise. Politically, the directors of the *Vivarium* were well connected to Tandler and had the support of the municipality. As it appears in the *Vivarium*'s annual reports published in the almanac of the Austrian Academy of Sciences, the

[39] Reiter, "Zerstört und vergessen," (1999), p. 592.
[40] Reiter, "Zerstört und vergessen," (1999), pp. 595-6.
[41] Koestler, *The Case of the Midwife Toad,* (1971), p. 23.
[42] Koestler, *The Case of the Midwife Toad,* (1971).
[43] Hofer, "The Beginnings of Biological System Theory," manuscript. See also Reiter, "Zerstört und vergessen," (1999), p. 608.
[44] Almanach der Akademie der Wissenschaften in Wien, (1932/33), p. 263.

Institute received several donations from the city of Vienna over the years.[45] Scientifically, the *Vivarium* was in a position to foster experimental biological research, as the study of the effects of radium on plants and animals required. The only thing missing was the expertise in working with radioactive substances. As the directors argued, a laboratory with focus on the biological effects of radium was necessary and would be complementary to the research done in the Radium Institute given the fact that a condition that Kupelweiser posed in 1910 restrained the latter from doing research on living organisms.[46] As Meyer described in 1950, "according to the protocol the participation in medicine for our institute was impossible, but at that time the reciprocal interest was big."[47]

What for the directors of the *Vivarium* was necessary, for the director of the Radium Institute was definitely a chance to enlarge the research agenda of his institute. Kinship relations between researchers and ideological proximity in the directorship and the working ethos between the two institutes promised an environment for fruitful research. The assistant of the Radium Institute, Karl Przibram, was the brother of Hans and one of those who financially supported the *Vivarium* when it was first established. Meyer's wife, Emilie Maas, was the niece of Leopold von Portheim.[48] Additionally, many of the researchers of the Radium Institute had already expressed their interest in working on the boundary between physics and medicine, such as Blau, Kara-Michailova, Rona, Eduard Jahoda, and Franz Urbach.[49] At that time Urbach was the director of the *Physikalische Laboratorium* at the municipal hospital in Lainz. In 1929 Meyer published on the physical basis of radium emanation therapy.[50] The next year he collaborated with Erhard Suess, the son of the president of the Academy Eduard Suess, on the use of radium emanation as an indicator for diagnostics and in therapy.[51] Meanwhile, Meyer supervised the work of Maria Renata Deinlein on the residence time of radon in the

[45] In the course of Red Vienna, the *Vivarium* received financial support from the city. Almanach, Akademie der Wissenschaftern in Wien, (1922), p. 180; (1923), p. 155; (1924), p. 189; The mayor Karl Seitz supported the installation of general heat system in the *Vivarium,* Almanach, Akademie der Wissenschaftern in Wien, (1926), p. 209; (1927), p. 205; (1928), p. 227.
[46] The directors of the Vivarium to the Kuratorium of the Vivarium, June 2, 1932, AÖAW; Meyer, "Die Vorgeschichte," (1950), pp. 12-3.
[47] Meyer, "Die Vorgeschichte," (1950), p. 19.
[48] Reiter, "Zerstört und vergessen," (1999), pp. 596.
[49] In 1922 Jahoda co-authored a paper with the radiologist Guido Holzknechkt on the luminosity of x-rays (Agetter, *Guido Holzknecht*, (1998), p. 69). In the Institute Jahoda was working at Przibram's group.
[50] Meyer, "Physikalische Grundlagen," (1929), pp. 557-580.

human body after drinking therapy.[52] In 1932 Meyer was invited to prepare a special issue of the *Pharmazeutische Presse* on radioactivity, in which he involved Przibram, Gerhard Kirsch, and Rona.[53] Thus, the proposal for a joint research radium laboratory that would be housed in the *Vivarium* seemed not only reasonable, but was also needed.

Besides the scientific concerns, the second stage of the proposal carried a political dimension. As the directors of the *Vivarium* revealed in their plan, the proposed laboratory would function as the regulator for the supplies, the dosimetry, the handling, and shipment of radium in Austrian hospitals.[54] It was one thing for the scientists to require a new research laboratory and it was quite another to envision themselves as the regulators of radium supplies in the hospitals of the whole country. In 1930 the establishment of the radium laboratory at the municipal hospital in Lainz, was already a persuasive sign of the Social Democrats' political plans to alter welfare services in Vienna. Meyer's position as the consulate for the radium purchases from the municipal hospitals, implied a direct connection to Tandler's political agenda. Thus, the proposal that was put forward from the *Vivarium* probably met Tandler's ambitions as well, and envisioning a centralized station for radium supplies that exceeded the borders of the city of Vienna. However, given the wider political crisis of the country, the timing was not propitious.

Five days later, impressively fast, a committee was invited to meet at 5:00 pm at the Academy to discuss the proposed project.[55] Among them were Meyer and Schweidler from the Radium Institute, and Hans Przibram and Portheim from the *Vivarium*. The president of the University of Vienna and an earlier collaborator with the Radium Institute, Hans Molisch, attended the meeting, along with Arnold Durig, the director of the Physiological Institute of the University of Vienna. Durig was member of the supreme hygiene councilors and one of the first to be dismissed for political reasons after the *Anschluss* in May 1938.[56] Unfortunately no further notes about the discussion appear in the protocol book of the Austrian Academy of Sciences. However, a letter to Molisch signed from both Prizbram and Portheim on

[51] Erhard Suess was a physician and lung specialist (Meyer to Kautz, May 11, 1934, AÖAW.)
[52] Meyer and Suess, "Zur Verwendung," (1930), pp. 613-628; Deinlein, "Verweilzeiten," (1933), pp. 127-134; Maria Renata Deinlein, Rigorosenakt 11725, AUW.
[53] Meyer to Kollassa, February 3, 1933, AÖAW.
[54] The directors of the Vivarium to the Kuratorium of the Vivarium, June 2, 1932, AÖAW.
[55] Protocol book of the Austrian Academy of Sciences, 1932, AÖAW. I thank the archivist Stefan Sienell for directing my attention to the protocol book of the Academy.

the 6th of June 1932, a day earlier than the actual meeting of the committee, sheds some light on the issue. After informing him that on Sunday they had 400 visitors and 80 children in the aquarium, they mentioned that, "unfortunately nothing will happen with the other project because the one who proposed it did not come in touch with us and the gathered information does not shed any favorable light on it."[57]

The proposed project never took place, thwarting the possibilities of interdisciplinary research on radiobiology. Less than two months later, on July 31, 1932, Steinach retired.[58] The failure of the *Vivarium* and the Radium Institute to establish a joint radium laboratory could be attributed to many factors. The fact that two of the most liberal institutes in Vienna required formally not only to play a scientific but also a political role in the country in a time of a deep anti-republican crisis is not negligible. Adding the fact that most of the researchers, especially those in the key positions of the directors, were Jewish, one could anticipate the outcome of the proposal. The unfruitful initiative was only a sign of what was going to happen in the political life and the scientific research of the country.

8.4. Franz Urbach and the Fascist Politics of Persecution

In its early days the new fascist regime in Austria was more interested in destroying the social democratic forces of the city of Vienna than in Jewish scientists. However, some fit in both categories. Franz Urbach, collaborator of the Radium Institute, was among the first to be fired from his position as director of the *Physichalische Laboratorium* at the municipal hospital in Lainz. The reason was clearly political but Urbach was also from a well-known Jewish family in Vienna.

Urbach completed his dissertation on the phenomena of luminescence after radioactive irradiation in 1926 under Przibram. He continued to work with him until 1932, when he was appointed as director of the *Physikalische Laboratorium* in the hospital in Lainz. According to Wolfgang Reiter, in 1934 the new municipal authorities expelled Urbach from his office, accusing him of gaining the position under the political influence of his uncle Otto Urbach, an active Social Democrat.[59] Besides this odd excuse, the fascist regime knew pretty well that Urbach had a key

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[56] Arnold Durig, Rigorosenakt, p. 3, AUW.
[57] Przibram and Portheim to Molish, June 6, 1932. Vivarium file, AÖAW.
[58] Bundesminister to the Präsidium der Akademie, July 1, 1932; Eugen Steinach, Rigorosenakt, AUW.

position similar to the one that the directors of the *Vivarium* envisioned to obtain through the joint laboratory with the Radium Institute, yet on a smaller scale. Indeed, the *Physikalische Laboratorium* of the municipal hospital created the space for interdisciplinary exchanges among physicists, technicians, and physicians. Binding together radioactivity and medicine, the physicists crossed the boundary of their expertise, providing scientific support to doctors over issues of radium dosimetry.[60] Employing a director, two physicists, and a technician, the laboratory offered technical support to the physicists who worked in the relevant pavilions of the hospital. Open to medical practitioners, it further functioned as a zone of collaboration between physicists and physicians for the development and improvement of methods applied in radium therapy. Nevertheless, besides playing the role of an information and research center, the *Physikalische Laboratorium* had another key function. It controlled the radium carriers, 400 in total, for medical use. The whole endeavor, as Urbach acknowledged, became possible through the municipality's initiative and the support of three professors of the University of Vienna: Meyer, Thirring, and Hermann Mark.[61]

For the fascists the removal of Urbach from his key position in the hospital at Lainz was an issue of control and demonstration of power. Red Vienna and the reforms of the Social Democrats were clearly past. The municipality was in the hands of the Christian Socialists and appointments were now controlled by Schuschnigg's regime. When Urbach found himself unemployed, the place to turn was the Radium Institute and his close collaborators there, Meyer and Karl Przibram. In the 1935 publication of the almanac of the Austrian Academy of Sciences, Urbach appeared as the Institute's collaborator, as he was before he obtained the position in Lainz.[62] The same year, working in Przibram's group, he published an article in the *Mitteilungen* on the spontaneous change of latent pictures.[63] He remained in the Institute until his immigration in 1939. [64]

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[59] Reiter, "The Year 1938," (1995), p. 198.
[60] Urbach, "Einiges aus dem Physikalischen Laboratorium," (1933), p. 537.
[61] Urbach, "Einiges aus dem Physikalischen Laboratorium," (1933), p. 537n.
[62] Almanach der Akademie der Wissenschaften, (1935), p. 197.
[63] Urbach, "Über eine spontane Veränderung," (1935), pp.
[64] Reiter, "The Year 1938," (1995), p. 198. Urbach's wife, Anni Urbach, entered the Institute in 1935. (Almanach der Academie der Wissenscaften (1935), p. 197). Daughter of the psychoanalyst Paul Federn, Freud's collaborator, Anni studied law and worked in a juvenile court. After her marriage to Urbach, she turned to physics. No publication appeared in the *Mitteilungen* under Anni Urbach's name. In the Institute's kassa, where Meyer recorded the finances, Anni appeared to have received minor

8.5. Hilda Fonovits-Smereker: A Puzzling Case

In these odd circumstances Hilda Fonovits-Smereker, *Assistentin* of the Radium Institute from 1919 to 1922, took over Urbach's position. The politics behind this appointment are not clear. In 1932 Fonovits-Smereker was hired as an assistant director at the *Radiumtechnische Versuchsanstalt*, the radium station at the General Hospital of Vienna.[65] The decision was made by the federal ministry for social administration and the ministry for justice. Most probably, nevertheless, the connection had been made through Meyer and the director of the *Radiumtechnische Versuchsanstalt*, Albert Fernau. That same year Fernau was in frequent correspondence with Meyer, discussing the therapeutic value of drinking water containing radon.[66] By that point, it was mainly the personnel of the Radium Institute that prepared radium for medical purposes in the general hospital. As Fernau mentioned, Rona had recently prepared radium D for hospital use.[67] Although no direct evidence exists, most likely under these circumstances Fernau suggested the hiring of a physicist and Meyer mentioned Fonovits-Smereker. The function of the *Radiumtechnische Versuchsanstalt* and thus Fonovits-Smereker' tasks were to measure and prepare radium for medical use.[68] She worked closely with Fernau until his death in 1934.[69] As Meyer informed Rona, who at the time was at Curie's Institute in Paris, "you probably have heard that poor Fernau died last August. He was not a

amounts of money probably for performing technical tasks (Kassa, 1933-1938, AÖAW). She remained in the Institute until their immigration in 1939.

[65] Hilda Maier, Lebenslauf, undated, Personalakt, AUW.

[66] As Fernau informed Meyer, Frederick Flinn, a radiologist from Columbia University in New York, visited him on August 25, 1932 (Fernau to Meyer, August 26, 1932, AÖAW). Flinn was involved in the case of Eben Byers whose death on March 30, 1932 shocked the medical community in the United States and prompted legislation acts concerning radium products. Since 1927 Byers, an internationally known industrialist from Pittsburgh, had been drinking as tonic a radium product called Radithor. He soon suffered from radium poisoning with symptoms similar to those of the radium girls, the famous case of the women licking their brushes while painting the dials of watches with luminous radium paint. (Clark, *Radium Girls* (1997); Rentetzi, "The Women Radium Dial Painters" (forthcoming).) Flinn was involved in both cases and tried in vain various methods to remove the radium from Byers' body. (Mullner, *Deadly Glow* (1999), pp. 114-118). Although in the radium dial painters' case Flinn refused to recognize the radium hazards working for the corporation that hired the women, in Byer's case he issued strong warnings against the use of radioactive products for internal use. (Mullner, *Deadly Glow* (1999), p. 69-70; Rentetzi, "The Women Radium Dial Painters" (forthcoming)) The national scandal of Byers' death prompted Flinn to travel to Vienna and also visit Paris and Berlin hoping to discuss with the international scientific community questions concerning radon therapy (Fernau to Meyer, August 26, 1932, AÖAW).

[67] Fernau to Meyer, September 19, 1932, AÖAW.

[68] Hilda Fonovits-Smereker, Lebenslauf, Personalakt, AUW.

[69] A co-authored article appeared in *Strahlentherapie* in 1933 on Byers' case. Fernau and Smereker, "Über das Verbleiben," (1933).

great scientist, but he was a very nice man and had achieved a lot for the dosimetry of medical preparations and not always was acknowledged. I have not yet heard more, whether and how his institute will be further directed."[70] Eventually, Fonovits-Smereker was promoted to his position but that was not the only change.[71] Based on a work contract, the city of Vienna, controlled by Schuschnigg's regime, entrusted the *Radiumtechnische Versuchsanstalt,* and thus its director, Fonovits-Smereker, to perform control measurements of the radium preparations and the rest of the scientific work previously done in the *Physikalische Laboratorium* at the hospital in Lainz by Urbach's group.[72] As her publication record reveals, the following years Fonovits-Smereker published extensively on medical physics and in a prestigious journal, namely *Strahlentherapie*.[73]

The *Oberarzt* of the radiation department, to which the *Physikalische Laboratorium* belonged, was Emil Maier. When the department was established under Tandler's supervision, Maier visited several sites in Europe in order to gain experience in radium therapy.[74] At the end of May 1938, right after the *Anschluss,* Maier became a member of National Socialists (NSDAP) and on December 1 of the same year was promoted to *Primararzt*.[75] In 1941, Fonovits-Smereker decided to share her life with Maier, performing her second marriage.[76] In 1943 her habilitation was accepted at the Medical Faculty of the University of Vienna and she retained the position of the director until the end of her life in 1954. Her death was attributed to severe blood damage due to her work with radioactive materials.[77]

Fonovits-Smereker's case is as a puzzling one. She was the only woman who ever held the position of a second assistant at the Radium Institute in the interwar years. Following an expected pattern of women in science she quit her career in 1922, unable to combine motherhood and scientific work. Nevertheless, ten years later she held a prominent position, this time as an assistant director at the *Radiumtechnische*

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[70] Meyer to Rona, September 12, 1934, AÖAW.
[71] Hilda Fonovits-Smereker, Lebenslauf, Personalakt, AUW.
[72] Hilda Fonovits-Smereker, Lebenslauf, Personalakt, AUW.
[73] See for example the articles published up to 1938. Smereker and Juris, "Messung der Beta-Strahlung," (1935), pp. 327-337; Schloss and Smereker, "Zur Radiumbehandlung," (1936), pp. 102-113; Smereker, "Untersuchungen," (1937), p. 267; Smereker, "Dosimetrische," (1937), p. 676; Smereker and Juris, "Versuche über die nicht directe Ionisierung," (1938), pp. 161-166.
[74] Emile Maier, Lebenslauf, Personalakt, AUW.
[75] Emile Maier, Lebenslauf, Personalakt, AUW; Emile Maier, Personalblatt, AUW.
[76] Bischof, *Frauen am Wiener Institut,* (2000), p. 68; Hilda Fonovits-Maier, Heiratsurkunde, Personalakt, AUW.
[77] Bischof, *Frauen am Wiener Institut,* (2000), p. 69.

Verschuchsanstalt in the general hospital of Vienna. In 1934, although the fascists ousted Urbach from the hospital in Lainz, she became the director of the *Physikalische Laboratorium*. No letters indicate any connection to the rest of the women at the Radium Institute and, to my knowledge, no evidence exists of her political positioning. Her marriage to Maier adds further complication to the story. However one chooses to explain Fonovits-Smereker' case, the point is that by working in a trading zone, that of radioactivity, she was able to be evasive and to cross disciplinary boundaries in order to regain entry into science. Carrying her physics expertise to the general hospital and then to the hospital in Lainz, Fonovits-Smereker secured a career in the border zone of medical physics.

8.6. A History of Disarray: The Institute for Radium Research, 1933-1938

From 1933 to 1938, the history of the Radium Institute, affected by the political upheavals, can be written as a history of disarray. Besides losing the full benefits of a position for a *wissenschaftliche Hilfskraft* in 1933, even the scientific connection to the second Physics Institute was threatened.[78] At the end of March 1934, Gustav Jäger, Exner's successor, was forced to retire as director of the second Physics Institute at the age of sixty-nine.[79] In a state of anxiety Stetter reported to Pettersson that "the disaster has already come. The ministry of education has informed the Faculty—in which form, I do not know—that Hofrat Jäger should retire by the end of March and that the second Physics Institute is dissolved."[80] On March 5, 1934, the same evening that Stetter wrote his letter, the Faculty was planning to meet and discuss its strategy. The special commission hoped to gain time by keeping Jäger for one more semester and to save the institute in some form or other. Although as Stetter admitted, "they" were not optimistic about saving Jäger, "they" proposed to mobilize the American envoy, concentrating their efforts on saving the institute. "The way through the ministry of foreign affairs is the one that can be successful. Perhaps an intervention from Rockefeller, perhaps a letter from Curie or similar?"[81] Stetter

[78] Meyer to Dekan, March 21, 1933, Karlik's file. Mitarbeiten/Assistenten, AÖAW; January 10, 1934. Berta Karlik's file, Mitarbeiten/Assistenten, AÖAW.
[79] Hittner, *Gescichte des studienfaches,* (1949), pp. 210. The reasons for his retirement are not stated.
[80] Stetter to Pettersson, March 5, 1934, GUA. Karlik conveyed the same information to Pettersson four days later without giving any specific reasons for the decision of the ministry (Karlik to Pettersson, March 9, 1934, GUA, translation mine).
[81] Stetter to Pettersson, March 5, 1934, GUA, (translation mine).

never explained who "they" were and as was obvious from Karlik's correspondence, a number of different strategies were proposed. "I had a very long talk with Kindinger who seems to have been discussing the matter with Stetter in details…I hope he has some influence on the others; his ideas about the tactic seem very sound."[82]

Stetter's main concern was that the dissolution of the institute would definitely affect his research. On the basis of his work in Pettersson's group, Stetter completed his habilitation in 1927 and six years later, in October 1933, he was promoted to an *ausserordentliche Privatdozent.*[83] Since 1922 he had been working as an *ausserordentliche Assistent* at the second Physics Institute and used its facilities for his research. Thus, with the dissolution of the Institute, Stetter's professional career was at issue. His fears also had another solid ground. Since 1932 he had been a member of the National Socialist Teachers League and, a month before Dolfuss banned the Nazi Party in July 1933, Stetter joined it.[84] On top of facing the dissolution of the second Physics Institute, Stetter was risking possible dismissal as an illegal Nazi.

Obviously Stetter was not the only one in the Institute who subscribed to the National Socialist ideology. Ortner had been a member of the National Socialist Teachers League since 1934. Kirsch, Pettersson's close collaborator during the 1920s, became a leader of a *Keimzelle* of the National Socialist Teachers League at the University of Vienna in 1933 and had been a member of the NSDAP since 1923.[85] Probably the most outspoken one of this group, Kirsch made Karlik and Pettersson nervous. Already in 1933 she expressed her disgust about him: "I have been to the Institute this morning. Kirsch has come back and now one has to face politics again. I feel so disgusted!!"[86] To Pettersson, a year later it became obvious that Kirsch's scientific work was "probably the least dangerous occupation one could find for him."[87] It was the time, as Karlik reported in her regular correspondence to him, that "many things are not pleasant" in the Institute, but letters did not seem to be a safe way for conveying more details.[88]

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[82] Karlik to Pettersson, March 9, 1934, GUA.
[83] Kommissionsbericht n. 59, Georg Stetter, Personalakte, AUW; The Dean to the ministry of education, December 20, 1933, n. 65, Georg Stetter, Personalakte, AUW.
[84] Galison, *Image and Logic,* (1997), p. 153.
[85] Galison, *Image and Logic,* (1997), p. 153.
[86] Karlik to Pettersson, September 13, 1933, GUA, (in English).
[87] Pettersson to Karlik, September 9, 1934, GUA, (in English).
[88] Karlik to Pettersson, April, 15, 1934, GUA, (in English)

In the meantime Karlik decided to apply for the position of *Dozent*. In the beginning of May 1936, she put together her papers and, as the procedure required, Karlik presented her file to all the members of the examination committee to ask whether they had any objection. "Schw.[eidler] was charming and addressed me kindly in all the formalities. Th[irrin]g—to my great surprise—took the question *au serieux*. Looked up the number of *Dozenten* we had already, asked me what I meant to lecture about and who was the last Doz.[ent] appointed and when was that and so on. But finally he round up by saying that, of course, he would not object, that he always had had an excellent impression from me and some more such compliments."[89] At that time Schweidler had been director of the first Physics Institute since 1920. In 1936 he was additionally appointed director of the second Physics Institute, which had remained without a director for two years after Jäger's retirement.[90] Thirring was director of the Institute for Theoretical Physics and already knew Karlik and her work, since he was on the examination committee of her doctoral thesis.[91] Felix Ehrenhaft, the director of the third Physics Institute and husband of Olga Steindler, one of the first women who graduated in physics from the University of Vienna, was next on the list.[92] They were all housed in Boltzmangasse next door to the Radium Institute and knew Karlik from the time she started her studies on radioactivity. However, with Ehrenhaft things did not go as smoothly as with the others. "He [Ehrenhaft] was 'terribly busy' for several days (Planck was in Vienna) and could not receive me. Then at last I was asked to come on Saturday, which was a day too late for sending the application for the May meeting of the Faculty. Whether he knew this or not, I don't know."[93]

Karlik was prepared for the delay and finally Ehrenhaft presented no objection. Even with their affirmations, nothing guaranteed the outcome of the final examination. She was planning to study during summer and present her colloquium the coming October. Given that Schweidler was the dean and also positive about her application, she expected to easily satisfy the formal requirements and complete the paper work in the next two upcoming faculty meetings before the end of the academic year. At the same time she continued to run her own experiments with uranium, part

[89] Karlik to Pettersson, May 12, 1936, GUA, (in English)
[90] Hittner, *Geschichte des studienfaches,* (1949), p. 79.
[91] Berta Karlik, Rigorosenakt 9765, AUW.
[92] Bischof, *Physikerinnenm* (1998), p.8.
[93] Karlik to Pettersson, May 12, 1936, GUA, (in English)

of her research project in Bornö. In addition she found herself "unexpectedly" busy with the task of performing photometric measurements for Thirring. "I don't mean to devote too much time to this job which is really not mine, but to go a little bit into the matter, I think will pay."[94] Accustomed to the collegial style of her earlier work at the Institute, she was hoping to learn a lot in various respects, "especially things which may also be of some use for your work," Karlik wrote to Pettersson. "I am glad also the thing is of interest to Schmidt, and Blau and Wambacher will also probably profit."[95] The arduous work and her numerous research obligations did not curb her willingness to go through with her application. As Pettersson assured her, "I have not the least doubts about your coming up out top dog in the end but you are in a strenuous time."[96] Eventually, Karlik received the *Venia Legendi* in 1937, the formal requirement for gaining the right to teach at the university. The winter semester of 1937/38 she started teaching on the physics of inert gases.[97]

Other than delays and an incredible amount of work, Karlik did not seem to have faced any serious objections. Blau, nevertheless, did not have a similar treatment when she asked for the permanent position of a *Dozent*.[98] According to her brother, a professor told her that to be a woman and a Jew was just too much.[99] Given that Karlik, was able to obtain the position, Blau's case indicates that gender was not the main factor in discrimination. The fact that Blau was Jewish and probably more politically engaged than Karlik contributed to her rejection.[100] The international attention brought by her success turned out to be a disadvantage instead of a supportive factor.

After her return from Paris in 1934, Blau continued her collaboration with Wambacher. The two women worked on two fronts. First, they improved the emulsion technique by thickening the photographic plates to allow a better deposit of the particle tracks. Ilford, the English photographic company, offered to produce sufficiently thick plates but as Blau explained, "to obtain still thicker emulsion layers,

[94] Karlik to Pettersson, May 12, 1936, GUA, (in English)
[95] Karlik to Pettersson, May 12, 1936, GUA, (in English)
[96] Pettersson to Karlik, August 3, (1936), GUA.
[97] Bischof, *Frauen am Winer Institut,* (2000), p. 108; Lintner, "Berta Karlik Nachruf," (1990), p. 304; Vorlesungen an der Universität zu Wien, 1937/18, AÖAW.
[98] Halpern, "Marietta Blau," (1993), p. 57.
[99] Galison, *Image and Logic,* (1997), p. 149.
[100] For some hints on Blau's political engagement see Miller to Solow, May 21, 1941, GDSCA; Solow to Bach, June 5, 1941, GDSCA; Interview of Arnold Perlmutter to the author, 1999, deposited in the AIP.

new developments methods had to be worked out."[101] Second, while still struggling to alter their apparatus to suit their experimental needs, Blau and Wambacher applied the photographic technique to neutron studies.[102] Nevertheless, their collaboration turned out to be threatening for Blau's existence in the Institute and for the control over her own method. In June 1934 Wambacher joined the National Socialist Party and around that time she was intimately involved with Stetter.[103] Facilitated by the political changes in 1936, Stetter soon started to interfere in the relationship of the two women and their scientific work.

That year, following Mussolini's suggestion, Schuschnigg sought an accommodation with the Germans. An agreement signed between the two countries led to the empowerment of the Austrian Nazis. The changes were immediately reflected at the Institute. As Karlik somewhat ironically reported to Pettersson, "Stetter is looking much interested in everybody's work and affairs and he is behaving like an ideal 'chef'."[104] What he was following very closely, though, was the work done by Blau and Wambacher. In 1936 the two women, supported by Victor Hess, the Institute's first assistant before the First World War and expert in cosmic radiation, exposed their emulsions on the Haferlekar, a mountain near Innsbruck, for four months. Their research project consisted in determining the existence of heavy particles such as protons, neutrons, and alpha particles in cosmic radiation, which at the time was quite doubtful. Proton tracks, longer than anyone else had observed by that time, were apparent in a first examination of the plates. Yet, to their surprise, the two women observed in the emulsion a "contamination star" (several tracks emanating from a point) that could neither be explained by irregularities in the emulsion nor from unknown radioactive products by the handling and storage of the plates in the laboratory. "This 'star' had to originate with cosmic radiation, since we had never observed a similar phenomenon in plates, even those that had been lying in the laboratory for much longer periods of time."[105] The assumption was that the large stars originated with the disintegration of heavy particles, probably bromine or silver, and the smaller ones originated perhaps from light elements in the gelatin. Given the theoretical limitations of nuclear physics of the time, Blau and Wambacher could not

[101] Blau, curriculum vitae, Leopold Halpern Papers
[102] For a detailed description of their experimental work see Galison, *Image and Logic,* (1997), p. 152.
[103] Galison, *Image and Logic,* (1997), p. 157.
[104] Karlik to Pettersson, February 11, 1936. GUA. (in English)
[105] Marietta Blau, curriculum vitae, Leopold Halpern Papers.

determine the nature of the primary particle and the exact process of the disintegration.

These impressive results, which Galison considers the first “golden event” using emulsions, provoked the interest of the scientific community and the brutal interference of Stetter.[106] In 1937, on the basis of their discovery, the two women were awarded the Ignaz Lieben Prize of the Austrian Academy of Sciences.[107] The international recognition came with Heisenberg’s immediate response. As Karlik informed Pettersson, “Heisenberg takes personally the most vivid interest in it [the new phenomenon] and is in continual correspondence with Blau and Wambacher. He has been talking about it in a conference with the Upper Ten in Bologna.”[108] While the two women were preparing a publication, Stetter approached Blau. He accused her of being unfair to Wambacher and expected her to change the order of the names on their publication. Wambacher after all, as Stetter argued, was the first to look into the microscope and find the first star.[109]

Interestingly enough, in 1927 the skill of observing scintillations, performed by the women of the Institute, was perceived by Chadwick and historically read as routine and technical, separate from the decisive parts of the experiment. In 1937 Stetter used Wambacher’s skill of observing and situating a star as the decisive part of the whole experiment performed by both women. Symptomatic of how the Viennese valued the task of observation, Stetter’s argument at the same time is ironically symptomatic of his ardent anti-Semitism. During the days of Meyer’s directorship, incidents like this did not occur. Yet the Nazi regime in the Institute imposed different practices. Although Stetter’s anti-Semitism is clear, his interference implies something more. Assuming his male power, he intervened in the relation of the two women,

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[106] Galison, *Image and Logic,* (1997), p. 154.

[107] In her self description written around 1963 Blau mentions that received the Haitinger Prize of the Academy in 1936. However, according to the records of the Academy Blau received the Lieben Prize in 1937 (Almanach der Academie der Wisssenschaften (1939), p. 136; Bischof, *Frauen am Wiener Institut,* (2000), p. 79; Pettersson to Karlik, June 7, 1937, GUA). From 1865 to 1937 Blau and Wambacher were the only women besides Lise Meitner (1925) that received the Lieben Prize. The only women from 1905 to 1938 who received the Haitinger Prize of the Academy were Rona and Karlik both in 1933 (Almanach der Akademie der Wissenschaften (1939), p. 141).

[108] Karlik to Hans Pettersson, December 30, 1937, GUA, (in English). I was not able to locate Heisenberg’s letters to Blau and Wambacher.

[109] Karlik to Pettersson, December 30, 1937, GUA.

taking control of their collaboration. Meyer, a Jew himself, was unable to play the leading role his position required.[110]

The colleagues that knew Blau, including Karlik, recognized that she was miserable after Stetter's intervention and even thinking of abandoning her research. Really close to Blau, Karlik knew very well that in spite of her poor health she had been working intensely for the last months, "the enormous pleasure the work gave her actually made her feel a little stronger."[111] As to Wambacher, "she certainly been very diligent, too, since the summer (chiefly examining the plates in the microscope) but Etta Blau has done all the very tiresome calculating."[112] And as Karlik reminded Pettersson, Blau was still the more "mature partner" between the two. At the same time, given her affair with Setter, Wambacher was strongly attached to him. Although, according to Karlik, she recognized that his taking up of the situation was not quite correct, her emotional dilemma was important. Her behavior towards Blau was extreme; being rude or often enormously generous, she turned the relationship to an uneasy one. The most suitable solution seemed to be for Blau to leave the Institute for a while. Karlik turned once again to Pettersson, asking for his intervention and suggesting that he could invite Blau to his institute, offering her a research project and a small stipendium.[113]

The solution came from another direction. Ellen Gleditsch, probably informed by Rona, took a personal interest in Blau's situation.[114] Her research assistant, Ruth Bakken, was pregnant and Gleditsch suggested that Blau replace her for three months. The solution was ideal. Away from Vienna, Blau could work with Ernst Föyn who she already knew through her summers at Bornö. Looking forward to her visit in Oslo, Blau arranged the matter with Wambacher. Nevertheless, the arrangement was a bad one for her. Even before Hitler's troops marched into the city, her Nazi colleague was able to take over the most interesting part of Blau's research project. Surrounded by the anti-Semites of the Institute, Blau did not have much of a chance to retain her research and gave in to an agreement that was a total defeat.

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110 On Meyer's personal difficulties under the Nazis see Reiter, "Stefan Meyer," (2001), pp. 106-27; Sime, *Lise Meitner*, (1996), pp. 287-88.

111 Karlik to Pettersson, December 30, 1937, GUA, (in English).

112 Karlik to Pettersson, December 30, 1937, GUA, (in English)

113 Karlik to Pettersson, December 30, 1937, GUA. The attempt to find a solution to Blau's problem was Karlik's initiative and nobody knew at the Institute the content of her correspondence to Pettersson, not even Blau.

114 Karlik to Pettersson, February 3, 1938, GUA.

Wambacher, in collaboration with Ortner, was going to investigate the relation of the grain and density of the tracks recorded on the photographic emulsions to the energy of the particles produced by them. By measuring the grain thickness of the tracks one could even estimate the energy of the particles that were not lying completely in the emulsion but passed through without ending it. That had the potential of identifying the particles and the total energy released in the projects, the two key points of Blau's and Wambacher's earlier work. "It is actually one of the main points started by Bl[au] in which she is particularly interested," as Karlik reported to Pettersson.[115] "Blau kept for herself the absorption experiments. It's less promising and more tiresome and it will take months before she can examine the first plates…she sacrificed more than I considered right."[116]

In his usual manner of supporting his women collaborators of the Radium Institute, Pettersson proposed to present Blau's work in the Swedish press. More urgent, nevertheless, was for Blau to give a paper at Bohr's institute on her way to Oslo. Wisely enough, Pettersson foresaw that the Bohr connection could pave her way to other prominent research centers in Europe.[117] Very cautiously and discreetly, Hevesy, who at the time was in Bohr's institute, arranged the visit for March 14, 1938.[118] The connection was made by Rona, Hevesy's earlier collaborator and friend.

While in the Radium Institute, Stetter, Ortner, and Wambacher orchestrated Blau's purge and the seizure of her scientific research, Kirsch tried to present the Nazi version of the two women's collaboration to Pettersson. For two months, in January and February 1938, Kirsch was on a scientific tour in Berlin, Kiel, Oslo, Stockholm and Göteborg, giving lectures on his work.[119] Travelling from Oslo to Stockholm, he visited Pettersson for an evening. That was enough for Kirsch to discuss the matter and allege that Blau had exploited Wambacher in their cooperative project.[120] Amid the threats of both those that surrounded her in Vienna and those who were willing to present to the international scientific community a version of the case convenient to Wambacher, Blau was ready to leave the Institute. Karlik expected that her leave would be temporary and both Blau and Wambacher "will find some way to each other

[115] Karlik to Pettersson, February 3, 1938, GUA, (in English)
[116] Karlik to Pettersson, February 3, 1938, GUA.
[117] Pettersson to Karlik, February 17, 1938, GUA.
[118] Blau to Bohr, March 5, 1938, NBA. Blau confirms to Bohr the information she got from Rona on the arranged colloquium in Copenhagen.
[119] January 20, 1938, Gerhard Kirsch, Rigorosenakt, p. 92, AUW.
[120] Pettersson to Karlik, February 20, 1938, GUA.

again after her return."[121] Karlik's naivete went so far to suppose that "Stetter already begins to feel sorry, but his *weltanschauliche* convictions and his sympathy for and his wish to help H[erta] W[ambacher] are very strong."[122] Contrary to Karlik's predictions, Blau's temporary distance from the Institute and her Nazi colleagues turned out to be a permanent struggle for existence. On March 12, Germans entered Austria in a triumphal parade. The day before Hitler gave his speech in Vienna, Blau left the city on a 7:00 a.m. train.[123]

8.7. *Anschluss* and Exile

To answer the question of "what was particularly Nazi in science after 1938 in Vienna," one should previously consider what was particularly different in the Viennese scientific community before 1934. As I have argued throughout, the physicists conducting research on radioactivity were an inseparable part of the Viennese culture and the democratic politics of Red Vienna. The collegial ethos of working in the Radium Institute and the leading style of Stefan Meyer defined the atmosphere in the Institute and welcomed a number of young scientists, many women among them. On the contrary, right after the *Anschlus*s, well-preserved patterns of research and cooperation were abruptly disturbed. The so-called "friendly visit"[124] of the German army to Vienna was not so friendly for the Jews of the Institute. Although the final decisions on the dismissed personnel were not expected earlier than the 10th of April, during the last week of March the scientists at the Institute were forced to swear allegiance to the Third Reich and at least two of them were excluded for racial reasons.[125] Meyer had already applied for a permanent retirement to the philosophical faculty on March 18 and voluntarily retreated from his Academy membership in an attempt to avoid any confrontation with the Nazis and the humiliation of a dismissal from the Academy.[126] Przibram's position was also threatened and, as Karlik described to Pettersson, "when I see Karl, tears come to my eyes."[127] Both Meyer and Przibram remained at the Institute as "guests" until January 1939, when a hate

[121] Karlik to Pettersson, February 24, 1938, GUA.
[122] Karlik to Pettersson, February 24, 1938, GUA. (in English)
[123] "Hitler Enters Austria in Triumphal Parade" *New York Times*, March 13, 1938; Blau to Paneth, March 21, 1938. AGMPG. I am grateful to Ruth Sime for pointing out this letter to me.
[124] Karlik to Pettersson, March 14, 1938, GUA.
[125] Karlik to Pettersson, March 30, 1938, GUA.
[126] Reiter, "Stefan Meyer," (2001), p. 122; Sime, *Lise Meitner,* (1996), p. 287-88.

campaign against them forced Ortner, the new director, to forbid their work at the Institute.[128] During the war Meyer and his family retreated to his summer residence in Bad Ischl, close to Salzburg. Przibram and his wife emigrated to Brussels.[129] As Wolfgang Reiter points out, after the *Anschluss* "the Radium Institute lost a quarter of its collaborators, in particular those who had shaped the profile of the Institute with their scientific achievements."[130] In front of the Radium Institute a long banner with the slogan, "one nation, one empire, one leader" made tangible the dramatic changes in the city and most obviously in the Institute itself.[131] Most expressive was the slogan hanging in the Physics Institute: "Juden sind hier unerwünscht" [Here the Jews are undesirable.][132]

While anti-Semitism in the Institute forced the Jews into exile, the promotions of the Nazi gang after the *Anschluss* were impressive. Besides taking over the directorship of the Institute, Ortner was named *Extraordinarius Professor.*[133] As Karlik explained,

> He [Ortner] is comparatively decent but perfectly happy and very pleased with what is going on. What he does not want to know he does not know and what he does not want to think he does not think about. So he is flourishing and has made a remark a few hours ago at which I felt I should like to smack his face. George's [Stetter] beaming satisfaction with himself is sometimes almost unbearable. His psychology is as primitive as can be. To have to listen to remarks and explanations by him and his friends is the greatest strain. Much worse even then to watch the distress of some friends.[134]

Ortner's friends, Stetter and Kirsch, were both promoted to the position of *Ordinarius Professor* and took over the responsibilities of those who left. "Gerhard [Kirsch] is now supervising the 3rd [Physics] Institute and is also lecturing 5 times a week in E.[tta Blau]'s place…George [Stetter] has taken over Charles's lectures."[135] By the beginning of May things went worse. "A number of changes have taken place here again. Mark, Thirring, Schrod., and Ludloff had to leave," Karlik wrote to Gleditsch.[136] Filling up the positions that the Jews such as Blau, Meyer, and Przibram

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[127] Karlik to Pettersson, March 14, 1938, GUA, (translation mine)
[128] Karlik, "1938 bis 1950," (1950), p. 35.
[129] Karlik, "1938 bis 1950," (1950), p. 35.
[130] Reiter, "The Year 1938," (1995), p. 195.
[131] Karlik to Pettersson, April 9, 1938, GUA (translation mine)
[132] Karlik to Pettersson, March 19, 1938, GUA.
[133] Galison, *Image and Logic,* (1997), p. 159.
[134] Karlik to Pettersson, July 2, 1938, GUA, (in English)
[135] Karlik to Pettersson, May 1, 1938, GUA, (in English)
[136] Karlik to Gleditsch, May 2, 1938, AÖAW.

left behind was not ambitious enough. The continuation of the research was accompanied by a plan of expansion. Supported by the German ministry for financial developments in Berlin, Stetter seemed to have played an instrumental role in establishing an institute for nuclear research as a joint program between the second Physics Institute and the Radium Institute.[137] The *Vierjahresplan-Instituts für Neutronenforschung* was directed by Stetter, and Ortner was his official substitute. As the Nazi authorities were not opposed to science, they channeled large amounts of money to scientific research and renovations. To accommodate the changes the Radium Institute underwent a decisive reconstruction. The whole building was cleaned and painted, the furniture was well washed, everything was put in order, and the door leading to the staircase towards the roof was bricked while another one was opened up. The aim was to eliminate the radioactive contamination in the Institute and use even the sensitive Geiger-Müller counters for measurements.[138] At the same time that the Jews of the Institute were cut off from their research and forced to exile, the Nazi circle, including Max Kindinger, Josef Schintlmeister, Willibald Jentschke, Stetter, Ortner, Kirsch, and Wambacher, secured the support of the Third Reich to play a role in the development of nuclear physics.[139] In this politically polarized atmosphere the non-Jewish but anti-Nazis, such as Berta Karlik, faced a crucial dilemma. “The question is: to stay or not to stay? I have decided to stay,” she admitted to Pettersson.[140]

8.7a. Berta Karlik

In 1938, anxious about the political circumstances, Pettersson proposed to Karlik, his closest friend and long time collaborator, a one-year fellowship in his new oceanographic institute in Göteborg. “Remember, I am reserving my first research fellowship for you and am moreover <u>not</u> pressing you for an answer. But in case you do not forfeature any changes where you are by coming I shall be very happy to have

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[137] Karlik, “1938 bis 1950,” (1950), p. 36. As Galison points out Stetter was a member of the commission met in may 1938 to consider the restructuring of physics in Viennan (Galison, *Image and Logic,* (1997), p. 158n.)

[138] Karlik to Pettersson, July 20, 1938, GUA; Karlik to Gleditsch, October 16, 1938, AÖAW.

[139] As Karlik reported to Pettersson, Max Kindinger was involved in the NSDAP with great enthusiasm after the *Anschluss* (Karlik to Pettersson, March 19, 1938, GUA). For Jentschke and Schintlmeister see Bischoff, *Frauen am Wiener Institut,* (2000), p. 140.

[140] Karlik to Pettersson, July 20, 1938, GUA, (in English).

you here in 1939."[141] The changes, however, where drastic. With Ortner as the new director and Przibram's purging from the position of the first assistant, Karlik took over his responsibilities and most of his research agenda.[142] The new arrangements brought her professionally very close to Ortner, a collaboration that threatened her own research agenda and her role at the Institute. "He [Ortner] is a bit of an egoist, too, in his work and there have already been a few incidents which showed me that I had to look out or he would use me as a well-qualified kuli, most comfortable to him."[143]

The changes in the directorship marked not only the rise of anti-Semitism within the Institute and the flourishing of the Nazi group but also tended to transform the role of women scientists. Out of the seventeen women at the Institute in 1938, only seven remained in 1939.[144] With the departure of Blau and Rona, the women most seriously engaged in the Institute's research, and the decrease in the total number of women, the responsibilities of those who remained increased. Yet, there was little place for research and less time for creative work. "It's not a matter of career," Karlik admitted to Pettersson.[145] "I hope you know me well enough to realize that I don't care for that. But I want decent conditions of work; not just endless drudgery work and a lot of responsibility in all sorts of silly little matters and the care for the stupid ones of the students."[146] Afraid that she would lose her research status at the Institute, in May 1938, Karlik prompted Pettersson to demand back the apparatuses he left in Vienna after his departure in the early 1930s. Financed by Swedish donors and the Rockefeller Foundation, the laboratory instruments used in the disintegration experiments of the 1920s officially belonged to Pettersson. During the 1930s, while he was still in close collaboration with the women of the Institute, Pettersson never claimed his instruments even when he was in need to equip the Station in Bornö. Wanting to ensure her access to the most important experimental apparatus for her work, Karlik asked Pettersson to leave in her responsibility the glass spectrograph. "Years ago Gerhard [Kirsch] hinted already at taking it away from me

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[141] Pettersson to Karlik, March 30, 1938, GUA, (in English)
[142] Karlik to Pettersson, July 20, 1938, GUA.
[143] Karlik to Pettersson, July 20, 1938, GUA, (in English)
[144] Alamanch der Akademie der Wissenschaften, (1938), pp. 193-4; (1939), pp. 192-93.
[145] Karlik to Pettersson, July 20, 1938, GUA.
[146] Karlik to Pettersson, July 20, 1938, GUA, (in English)

should he once leave Vienna. Perhaps it was more to show his power over me at that time that he actually meant it—anyhow I am not safe."[147]

While Karlik was struggling to retain her research position in the Institute, she was assigned the reorganization of the library, Przibram's administrative tasks as assistant, several odd jobs in the renovation of the building, and the supervision of a number of young students besides her own.[148] With a feeling of ambivalence, "torn to pieces," Karlik decided to stay and rejected Pettersson's offer to take up the fellowship in his oceanographic Institute in Göteborg. "I will have to put up with many things, I want at least the possibility to do some research that interests me."[149] But it was not only the research Karlik was interested in. As she admitted to Gleditsch, "I think perhaps some of my English friends wonder why I am not leaving Germany in protest. I have come to the conclusion that protest on the part of a German individual is quite useless at the moment and that more is done by staying and trying to improve matters from in the country."[150]

Indeed, Karlik remained in Vienna and during the war years she reached the peak of her career. In 1940 she officially became *wissenschaftlichen Assistent* at the Radium Institute and in 1942 she was promoted to *Diätendozentin.*[151] In collaboration with Traude Cless-Bernert, she discovered the natural occurrence of isotopes of astatine by observation of their radioactive alpha particle decays.[152] Bernert was supervised by Ortner and after her graduation in 1939 she remained at the Institute. The two women worked extensively together until 1945.[153] By the end of the war, after Ortner's "disappearance," Karlik became the director of the Institute and retained her position until her retirement.[154] In 1956 she was promoted to the highest academic rank that, of an *ordentliche Professor*, the first woman in Austria in such a

[147] Karlik to Pettersson, May 1, 1938, GUA, (in English)
[148] Karlik to Pettersson, May 11, 1938, GUA.
[149] Karlik to Pettersson, July 20, 1938, GUA.
[150] Karlik to Gleditsch, September 11, 1938, AÖAW, (in English).
[151] Berta Karlik, Curriculum vitae, 1949, Rigorosenakt, p. 104, AUW.
[152] Karlik and Bernert, "Über eine vermitete" (1942), p. 685. Karlik, "1938 bis 1950," (1950), p. 36. See also http://www.physics.ucla.edu/~cwp/Phase2/Karlik,Berta@900123456.html, (last checked on January 17, 2003).
[153] Karlik and Bernert, "Zur Frage," (1942), pp. 255-265; Karlik and Bernert, "Über die Entemanierung," (1942), p. 267; Karlik and Bernert, "Über eine dem Element," (1943), pp. 103-110; Karlik and Bernert, "Das Element 85," (1943), p. 51; Karlik and Bernert, "Eine neue natürliche alpha Strahlung," (1943), p. 298; Karlik and Bernert, "Ein weiterer dualer Zerfall," (1943), p. 492; Karlik and Bernert, "Das Element 85," (1944), p. 44; Karlik and Bernert, "Über swei neue Alpha-Strahlungen," (1944), pp. 2-3; Karlik and Bernert, "Entsehung," (1945), pp. 34-35.
[154] Karlik, "1938 bis 1950," (1950), pp. 37-38.

position. The Austrian Academy of Sciences elected her as a member in 1973, the second woman member of the Academy after Meitner.[155]

8.7b. Elisabeth Rona

Although Karlik had the choice to remain at the Institute, Rona had to flee. On April 7, 1938, she left for Budapest, so upset and disturbed by the new political status that she abandoned her research and left her latest measurements in disarray.[156] On a letter written the same day, Karlik admitted to Gleditsch, "I have just seen Elisabeth off. I am going to miss her <u>very</u> much. We got more attached to each other in those weeks then ever, but we both felt that it was time she was going; this atmosphere of departure was becoming to tear our nerves."[157] One of Rona's last papers published in the *Mitteilungen* was in collaboration with the Nazi Josef Schintlmeister, who was under Stetter's influence.[158] It was not only the rise of the Nazis within the Institute that threatened Rona, but her every day life became troublesome as well. "She has had to provide innumerable certificates concerning taxation, etc. and everywhere she had to queue up. Every day brought new regulations that meant some more certificates. There was a very severe control of the luggage already at the station but I hope," Karlik continued, "she will get home safely."[159]

At the age of forty-eight and after thirteen years of work at the Radium Institute, Rona was in search of a new job. Pettersson was ready to offer her a position in Bornö for three months in the autumn, replacing his assistant, Börje Kullenberg, who was going to work in the new oceanographic institute in Göteborg.[160] Given that Hungary was still independent, Rona left for Budapest, where she considered working at the university.[161] Dissatisfied with the conditions there, she instead worked in

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[155] On Karlik's scientific career and life see Bischoff, *Frauen am Wiener Institut,* (2000), pp. 101-119; Lintner, "Berta Karlik Nachruf," (1990). Vogt, "Women Members of the Academies of Science," (2000).

[156] Karlik to Pettersson, April 9, 1938, GUA, (in German); Karlik to Pettersson, May 11, 1938, GUA, (in English).

[157] Karlik to Gleditsch, April 7, 1938, AÖAW, (in English)

[158] Rona and Schintlmeister "Untersuchung der Alphastralung," (1938), pp. 49-62. Schintlmeister worked closely with Stetter starting in 1934 (Karlik to Pettersson, March 9, 1934, GUA). During the National Socialist period Schintlmeister became Stetter's assistant and promoted to *Dozent* for experimental physics in 1939 while he was a member of the NSDAP (Bischof, *Frauen am Wiener Institut,* (2000) p. 140).

[159] Karlik to Gleditsch, April 7, 1938, AÖAW.

[160] Pettersson to Karlik, March 30, 1938, GUA, (in English).

[161] Karlik to Pettersson, July 27, 1938, GUA.

industry. As she informed Meyer, "the possibility of work for the immediate future makes me worry a lot. I have found a comfortable job in the Vatur industry through the kindness of the director Patai."[162] She was able to retain the job until September of 1938, when the industry shifted to mere production, eliminating laboratory positions. Threatened by the political upheavals in the neighboring countries, Rona was hesitant to accept Pettersson's invitation. In the absence of any other option, the woman who was one of the most distinguished experts in polonium preparations eventually spent October through the end of December in Sweden working on oceanography.[163] Her close friend Gleditsch offered her another temporary solution. She invited Rona to spend a year in Oslo replacing a staff member in her laboratory, who was on a leave of absence.[164] "We have had much trouble in getting the permission for Dr. Rona to enter Norway. I believe however, that by now everything is in order," as Gleditsch informed Karlik on January 17, 1939.[165]

By the end of her stipendium in Oslo, Rona returned to Budapest in 1940. Working in the boundary of physics and medicine and taking advantage of her earlier experience preparing radium for hospital use, she obtained her next one-year position at the Radium-Cancer Hospital in Budapest.[166] Nevertheless, as she later recalled, "In 1941 I made a big decision. Hungary was threatened from two directions; one side, the right bank of the Danube, were the Russians; on the left, the Germans. There was no future for me in Hungary."[167] After a last visit in Vienna in January 1941, Rona fled to the United States on a visitor's visa. Hunting for a job in the annual meeting of the American Physical Society, she was able to obtain her first position at the Trinity College, a Catholic College for women in Washington D.C., as a chemistry teacher. Her earlier work in another trading zone that of radioactivity and oceanography, was the vehicle for securing a joint research position at the Geophysical Laboratory, at the Carnegie Institute in Washington. Rona's experience at the oceanographic laboratory in Bornö appealed to C. Piggot and W. Urry from the Geophysical Laboratory as they investigated the radioactivity of ocean sediments. A year later she was invited to work for the Office of Scientific Research and Development (OSRD), using her expertise

[162] Rona to Meyer, July 7, 1938, AÖAW. It is not clear from Rona's letter what kind of industry was Vatur.
[163] Rona to Meyer, October 3, 1938, AÖAW, (translation mine)
[164] Rona, *How it Came About*, (1978), pp. 42-43.
[165] Gleditsch to Karlik, January 17, 1939, AÖAW, (in English)
[166] Rayner-Canham M. and Rayner-Canham, G., "Elizabeth Rona," (1997), p. 214.
[167] Rona, *How it Came About,* (1978), p. 53.

on preparing polonium for work related to the war effort. Obtaining security clearance, Rona passed her method to the Canadian Radium and Uranium Company, which had contracted the mass production of polonium for the OSRD.[168] Without any compensation and accustomed to the collegial ethos of doing physics during the interwar years, Rona generously offered the knowledge she obtained at the Radium Institute in Vienna and Curie's laboratory in Paris to her colleagues in OSRD. She was fortunate to be directly needed for the secret work on the atomic bomb and thus she was able to forge a career anew in the United States.

8.7c. Marietta Blau and Hertha Wambacher

The day that the German troops marched into the city of Vienna, Blau was on her way to present her work at Bohr's Institute in Copenhagen. After a successful talk, "she was tired and rather miserable" when she finally visited the Petterssons for a few hours on her way to Oslo in mid-March.[169] In Vienna she had left her mother and was anxious about her return but, as Pettersson assured Karlik, "Ellen Gleditsch will do her a lot of good and put her to hard work which is the most important point."[170] He was planning to bring her to Sweden during the summer and carefully mobilized his connections for a more permanent solution.[171] Simultaneously, Karlik kept in touch with Blau but wisely screened the news she conveyed to her and hid the fact that in the meantime her aunt died and her mother was hospitalized with a broken leg.[172] She further encouraged Pettersson to claim back the instruments he brought to the Institute in the early 1920s, the tabletop, portable objectives and microscopes that could be of use for Blau or even Rona, who were searching for a research position. "There is also Etta [Blau] to think of and perhaps even Elisabeth to consider. Especially as regards Etta some help might perhaps be offered to her by the loan of instruments. Heaven knows what her fate is going to be."[173] Indeed, Blau's fate was eventful. She was

[168] Rona, *How it Came About,* (1978), pp. 56-7.
[169] Pettersson to Karlik, March 30, 1938, GUA; Blau to Bohr, March 5, 1938, NBA.
[170] Pettersson to Karlik, March 30, 1938, GUA, (in English).
[171] Pettersson to Karlik, March 30, 1938, GUA, (in English).
[172] Karlik to Pettersson, May 11, 1938, GUA, (in English). Karlik sent a microscope table to Gleditsch in Oslo, on March 25, after Blau's departure from Vienna (Karlik to Gleditsch, April 7, 1938, AÖAW). She also planned to send a counter for Blau and Föyn to repair and work with it (Karlik to Gleditsch, May 2, 1938, AÖAW).
[173] Karlik to Pettersson, May 1, 1938, GUA, (in English).

forty-four years old when she was forced to start a new career, first in Mexico and later on in the United States.

In a letter of April 18, 1938, Einstein addressed the American Association of University Women, asking "how it may be possible to find a position for Miss Blau where she can continue her research."[174] Easther Brunauer, associate in the international education of University Women, responded immediately but with unfortunate news. She promised to do whatever possible, but although not explicit, their priority was Meitner. James Franck had already informed them that she was to lose her position at the Kaiser Wilhelm Institute. Concluding her letter, Brunauer asked Einstein to keep Meitner in his mind "if you hear of any opening at a research institute where you think her line of work might be developed."[175] Einstein's attempts to secure a position for Blau in the United States were not successful. In July, Bakken, Gleditsch's assistant, returned to the Institute and Blau planned to do translations in order to survive in Sweden.[176] In the meantime Einstein arranged a position for her at the Polytechnic School in Mexico City.[177] In November, after a delay due to formalities, Blau left Sweden. In her way to Mexico, the Gestapo confiscated her scientific notebooks after forcing her zeppelin down in Hamburg. As Blau later speculated, those ended up at the hands of her Nazi colleagues in Vienna.[178]

With or without Blau's scientific notebooks, Wambacher continued to use the experimental facilities of the Radium Institute when her Jewish colleague was in a desperate search for a research position and depended on Pettersson to secure some of her instruments in Vienna. The rupture between the two women was definite. Wambacher had been an applicant for the NSDAP party since 1934 and heavily depended on Stetter for her scientific and emotional life.[179] As Karlik acknowledged,

[174] Einstein to McHall, April 18, 1938, AAUW.
[175] Brunauer to Einstein, April 22, 1938, AAUW.
[176] Karlik to Pettersson, May 11, 1938, GUA, (in English); Karlik to Pettersson, July 17, 1938, GUA, (in English).
[177] Galison, *Image and Logic,* (1997), p. 155.
[178] According to Halpern the Gestapo confiscated Blau's scientific notebooks in 1938 as she was leaving Germany from Hamburg. The fate of those notebooks is not clear. However, Stetter's and Wambacher's later publications indicate a relation to Blau's missing scientific notes. As Galison suggests "although we may never be able to confirm this, we can know something of Wambacher's attitudes in the years of Nazi rule" (Galison, *Image and Logic,* (1997), p. 157). Karlik's letters to Pettersson suggest that Wambacher and her Nazi colleagues seized Blau's research much earlier than Gestapo's confiscation.
[179] Galison, *Image and Logic,* (1997), p. 157; Karlik to Pettersson, December 30, 1937, GUA, (in English).

"H[erta] W[ambacher]'s moral inside, I believe, is in a great mess."[180] Impressively fast, within two weeks of the *Anschluss,* Wambacher was promoted to the position of assistant at the first and second Physics Institutes, which were now combined and directed by Stetter.[181] The following year she received her habilitation based on the work on the "nuclear disintegration through cosmic radiation in the photographic emulsions."[182] That enabled her to become *Dozentin* in 1940, and the winter semester of 1941/42 she started teaching at the University of Vienna.[183] Publications in major German journals such as the *Zeitschrift für Technische Physik* and *Physikalische Zeitschrift* accompanied her rapid promotion in the university ranks.[184] Nevertheless, by the end of the war and although her Nazi male colleagues such as Stetter, Ortner, and Kirsch maintained the power they gained during the National Socialist period, Wambacher lost her previous advantages.[185] In 1950 she died fairly young in the age of forty-six.

In the meantime Blau was in search for a permanent position far away from Vienna, on another continent. In 1941 after an unfortunate research period in Mexico, she tried to enter the United States for a second time.[186] In a letter of May 21, Alvin Johnson, director of the New School of Social Research wrote to Thomas Appleget at the Rockefeller Foundation concerning her case. She had just lost her position in Mexico and was looking for employment. As Johnson concluded, "I have informed her friends that our project does not cover cases in Latin America."[187] The very same day Herbert Solow passed Blau's file on to H. Miller from the Rockefeller Foundation with the following note

> Perhaps you will be interested to know that her friend Mrs. Szego has told me that she thinks the reason for the failure of the Polytechnic School to renew the Blau contract has to do with some not too happy political shift since the last Mexican election. Dr. Blau is a Jewish refugee from Vienna and some of her relatives were Viennese

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[180] Karlik to Pettersson, February 24, 1938, GUA, (in English).
[181] Bischof, *Frauen am Wiener Institut,* (2000), p. 139.
[182] Wambacher, "Kernzertrümmerung," (1940), pp. 157-211.
[183] Bischof, *Frauen am Wiener Institut,* (2000), p. 139.
[184] Wambacher, "Mehrfachzertrümmerung," (1938), pp. 569-576; Wambacher, "Mehrfachzertrümmerung," (1938), p. 883; Wambacher, "Wirkung," (1939), pp. 38-62; Stetter and Wambacher, "Neuere Ergebnisse," (1939), pp. 702-6; Wambacher, "Höhenstrahlung und Atomkernbau," (1940), pp. 116-121.
[185] Bischof, *Frauen am Wiener Institut,* (2000), p. 139.
[186] For Blau's work in Mexico see Galison, *Image and Logic*, (1997), pp. 155-6.
[187] Johnson to Appleget, May 21, 1941, GDSCA.

> Socialists. Conceivably, she could be the victim of any of a half a dozen of conflicting types of factionalism.[188]

On May 23 Solow tried to put Blau in touch with Fritz Bach, Director of the *General de Estadistica* in Mexico asking for an advice, since he did not know her personally. It was Blau's friend, Szego, who brought the case to Solow's attention.[189] Within three days Blau's request was put in the drawer. In a letter of May 26, 1941, Appleget informed Johnson that there was no possibility of assistance under their present program.[190] Bach's response to Solow on June 5 sheds light on the case. Despite her contract with the Polytechnic in Mexico, Blau's payment was suspended. The official reason was the lack of money. As Bach admitted, "I believe that the reasons may be different. At the Ministry of Education the Stalinists are still strong and she, without being a Stalinist, of course, has always been in close contact with them. I do not want to take care of this matter, mainly because of the kind of friends she has, and besides, I do not think that I would succeed."[191] As Blau's situation was "rather delicate," both the New School for Social Research and the Rockefeller Foundation did not take the risk of pursuing her case. Blau remained in Mexico for three more years. When she finally entered the country in May 1944 she was on leave from the *Escuela Tecnica Superior* until December but she never returned.[192] It was probably through the attempts of the Jewish community in Mexico that Blau was able to find her first position in industry, working for the International Rare Metals Refinery, in New York.[193]

8.8. Women's Lived Experiences in a World in Transition

Ideology, as the system of ideas and representations that one holds and according to which one acts, is inscribed in the everyday practices and choices of

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188 Solow to Miller, May 21, 1941, GDSCA.
189 Solow to Bach, May 23, 1941, GDSCA.
190 Appleget to Johnson, May 26, 1941, RAC.
191 Bach to Solow, June 5, 1941, GDSCA.
192 Blau to Venegas, April 14, 1944, E.S.I.M.E. Blau asked the director of E.S.I.M.E. to grant her a leave of absence from May 1 to December 31, 1944.
193 The *Comite Central Israerita de Mexico* contacted the World Jewish Congress in New York as well as the Canadian Government Trade Commissioner asking for a possible position on behalf of Blau (Glikowski to Tartakower, no date, CDICAM; Lisker to the Canadian Government Trade Commissioner, February 10, 1942, CDICAM). They also financially supported Blau when her mother was sick and in need of a person constantly next to her during the difficult years 1942-43 (Blau to

individuals. While in the relevant literature Social Democracy has been coded as political pluralism, National Socialism has often been characterized as ideology, certainly applying a negative meaning to the term. One should not forget, nonetheless, that Social Democracy in Austria during Red Vienna carried and implemented an ideological apparatus as well, arguing for and using democratic procedures. In contrast and without doubt, totalitarian and authoritarian as they have been, nazi and fascist ideologies repressed democracy and cruelly invaded the autonomy of the individual. In a totalitarian regime, as Austria was after 1933, the first to be targeted was the educational system. The decline of the *Mediziner-Viertel* was only a symptom of how Christian and National Socialist ideologies tried to transform the Austrian society. The purge of outspoken liberal and social democratic faculty and staff members of the Vienna University, the racial politics enacted especially after the *Anschluss,* and the use of brutal violence were part of the ideological apparatus that fascists and Nazis mobilized and used to exercise their power. That ideological apparatus was put forward to produce students educated in race, science, and in new population policies, to transform the university through dismissals and changes in positions, and to take total control of key positions that the Social Democrats managed to obtain in their term. By 1938 the entire range of educational reforms and social and cultural policies of Red Vienna was destroyed on the basis of an anti-Semitic and anti-Social Democratic propaganda and exercise of political power. The dissolution of the Vienna Circle, the Ernest Mach Society, and Neurath's Social and Economic museum, as well as the obstruction of the research agent of the Radium Institute, the *Vivarium*, and a number of other "red" institutes, occurred before Hitler's arrival on the Austrian scene and was accomplished by the earlier fascist regime.

During the fascist regime changes in the Radium Institute did not concern directly its structure. Probably because it was an institute devoted to research and not to education, the fascists had less interest in transforming the Institute's internal hierarchy and in dismissing its undesirable personnel. For strategic reasons their interest was focused on institutions and educational establishments with direct influence to the public and the young generation of students. It is indicative that most of the Institute's personnel continued research in respectively the same manner as

Comite Central Israelita de Mexico, November 3, 1942, CDICAM; Glikowski to Blau, May 17, 1943, CDICAM).

before. Karlik succeeded in becoming *Dozent* and the Jewish Blau shared the Lieben Prize awarded by the Austrian Academy of Sciences with Wambacher. The purge and transformation of the University's and the Academy's members had not been radical yet. The fascist regime, however, thwarted Meyer's ambitions to elevate the Radium Institute to a national regulator of radium supplies for medical use and cut the Institute off from any key role that could have in the municipal level. After the *Anschluss* science was turned into a servant of state ideology. The fate of the Radium Institute was absolutely on the hands of those who saw in politics a chance to rise in scientific ranks and impose their worldviews. Stetter, Ortner, and the rest of the Institute's Nazis were able to establish their order and fulfill their ambitions. What could it mean to be a physicist in such a context? Karlik's agonizing over the question of remaining in Austria and pursuing research in the Institute or leaving gives a glimpse of possible dilemmas experimenters had to face.

To sharpen the question: what could it mean to be a Jewish physicist then and particularly a woman Jewish physicist? As Doris Bergen argues, "any study of women as outsiders in Nazi Germany and German-occupied Europe is necessarily a discussion of race; it is not possible to separate sex from blood in Nazi ideology and practice."[194] The National Socialist ideology constructed gender as intertwined with and inseparable from race. However, to reduce women to either one or to suggest that both factors added to what meant to be a woman in Austria is to argue against the complexity of how subjectivities were and are formed. What it meant to be a woman (and a man as well) was the outcome of women's (and men's) location with a range of different situations such as their sexed bodies, race, nationality, religion, and ideological commitments. However, this outcome could be reduced to neither of these situations nor to be perceived as the sum of all. As, for example, the Blau-Wambacher case indicates, the complexity of their story cannot be captured by reducing the historical analysis to the interplay of gender and race as two distinct factors. Their set of practices can be only understood by focusing on what they integrated to over time, their lived experiences.

[194] Bergen, "Sex, Blood, and Vulnerability," (2001), p. 273.

CHAPTER 9
INSTEAD OF AN EPILOGUE
MARIETTA BLAU ON THE MARGINS OF NUCLEAR AND PARTICLE PHYSICS

With the end of the World War II, the first attempt to bring the scintillation counter back into nuclear research coincided with the passage from what Galison has described as the image to the logic tradition in physics. As he argues, "what transformed the scintillator's flash and Cerenkov's glow into basic building blocks of the logic tradition was the electronic revolution begun during the war. When attached to the new high-gain photomultiplier tubes and strung into the array of amplifiers, pulse-height analyzers, and scalers that emerged from the Rad Lab and Los Alamos, then and only then did the scintillator and Cerenkov radiation became part of the material culture of postwar physics."[1] Interestingly enough, one of the first to suggest the use of a photomultiplier in combination to the scintillation counter was Blau. Nurtured in the material culture of the Radium Institute before the war, she sought possibilities for professional existence in saving the scintillation counter. It was through the instrument that Blau mingled the competing prewar and postwar cultures in physics research.

As Arnold Perlmutter has argued, although Blau found herself "at the periphery of the American research establishment," she "led to an explosion of creative activity."[2] Working at the physics department of the International Rare Metals Refinery, Blau teamed up with B. Dreyfus in combining the use of a photomultiplier tube to a scintillation screen for the measurement of alpha ray sources.[3] As the references to Kara-Michailova's and Karlik's work show, the driving force in designing the device was Blau. Drawing on her work and that of her colleagues in the Radium Institute in Vienna from more than a decade ago, Blau relied on her past to secure her present. In 1933 and after abandoning the ordinary scintillation counter, Karlik worked on the determination of alpha particle ranges utilizing a photoelectric cell while she kept the fluorescent screen as the intact part of

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[1] Galison, *Image and Logic,* (1997), p. 454.
[2] Perlmutter, "Marietta Blau's Work After World War II," (unpublished manuscript), p. 2.
[3] Blau and Dreyfus, "The Multiplier Photo-Tube," (1945), p. 245-248.

the instrument.[4] Karlik's method, however, was seldom used, as Blau explained, given the limited range of measurements of the ordinary photo-cells and the lack of adequate and constant alpha-standards. "These two inconveniences," she continued, "have been remedied recently, thanks to the appearance of the multiplier photo-tube, and of good standards."[5]

The continuity of technology traced from Dagmar Pettersson's version of the scintillation counter in 1923 to Karlik's 1933 counter equipped with a photocell and Blau's detector endowed with photomultiplier in 1945 is striking. Karlik replaced the microscope used in the early type of the scintillation counter attached directly to the scintillation screen by a photocell that Blau eventually turned it to a photomultiplier.[6]

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[4] Karlik, "Eine Lumineszenzmethode," (1933), pp. 115-119. Karlik presented the modified scintillation counter on February 23, 1933 at a Vienna Academy meeting. During the same meeting she also presented her work with Rona on the use of the instrument for the study of ranges of alpha-particles emitted from actinium and its products (Karlik and Rona, "Untersuchungen der Reichweite," (1933), pp. 121-126).

[5] Blau and Dreyfus, "The Multiplier Photo-Tube," (1945), p. 246.

[6] Karlik's device was similar to the one that Adolf Krebs developed in 1941. Krebs was a staff member of the Kaiser-Wilhelm Institute for Biophysics in Frankfurt since 1937. In 1947 he became director of the division of Radiobiology of the U.S. Army Medical Research Laboratory at Fort Lnox (Krebs, "Ein Demonstrationsversuch," (1941), pp. 330-332). See also Rheinberger, "Putting Isotopes to Work," (1999), p. 7; Krebs, "Early History of the Scintillation Counter," (1955), pp. 17-18.

Figure 9.1 The scintillation counter used by Dagmar Pettersson in 1922. (P) is the source, (F) is the absorbing foil and (Z) is the scintillation screen where a microscope was directly attached.

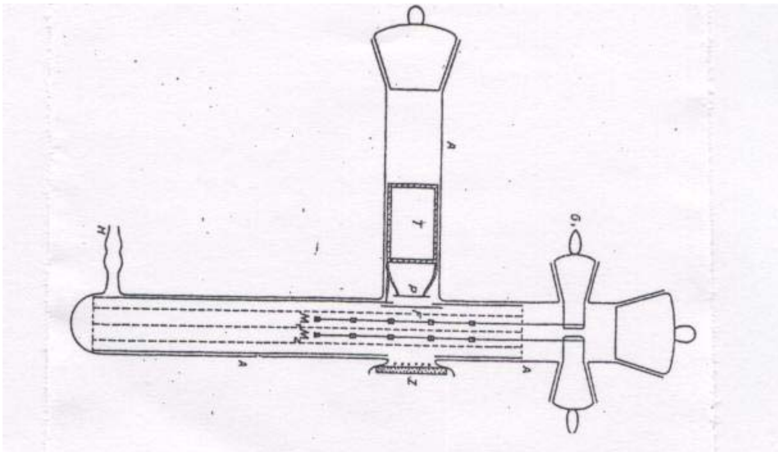


Figure 9.2 The scintillation counter designed by Berta Karlik in 1933. (P) is the source, (G) is a mica filter, (S) is the scintillation screen and attached is the photoelectric cell leading to an electrometer.

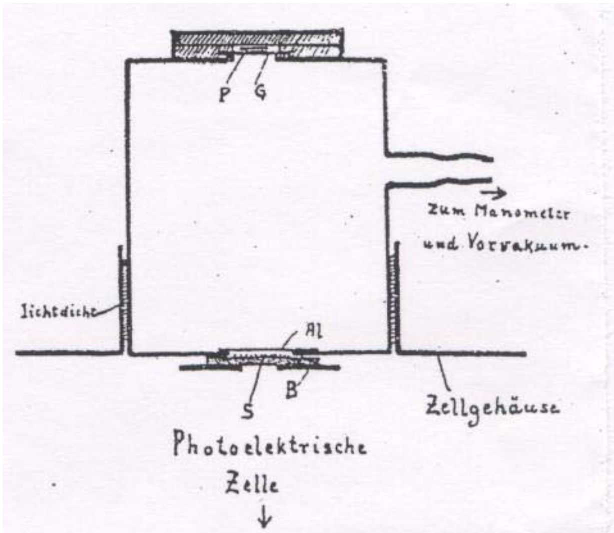
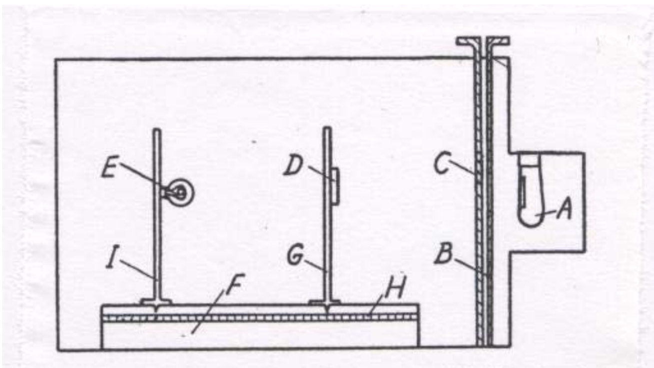


Figure 9.3 The scintillation counter that appears in Blau's and Dreyfus paper in 1945. (A) is a phototube enclosed in a metal box together with the optical bench (F) where stands the light-standard (E) and the alpha source (D), both mounted on movable carriages (G,I). The scintillation zinc sulfide screen (B) stands in front of the source and (C) is a removable shutter. The light-standard used to test the response of the tube to the light-emitting source.



Already in 1933 the shift from the microscope to the photocell was an attempt to save the scintillation counter by excluding the observer. Instead of the fragile and unreliable human optical system, Karlik introduced a sensitive electric device for the detection of the scintillations. The method, nevertheless, was barely noticed, not only because of its limitations but mostly due to the fact that the scintillation counter had already failed in the experimental tradition of the Institute. The end of the Vienna and Cambridge controversy brought the end of the counter as well. The political upheavals that followed in the country and greatly affected the life in the Radium Institute determined specific research directions that did not include the scintillation counter. After the end of the war, the second shift, this time from the ordinary photocells to photomultipliers in Blau's experimental practice, was not just a simple replacement between two pieces in an instrument. The transformation was deeper and a conceptual one for both the experimenter and her instrument. From a research-oriented position in the Radium Institute in Vienna, Blau's occupation shifted to industrial physics in the postwar United States. While in Meyer's Institute Blau was challenged by the scientific community to legitimize her theories and instruments, in her new position she was struggling for her mere existence. Her new concerns were the "wide range of applications" and the possibilities the photomultiplier scintillation counter offered for "quick industrial measurements."[7]

Putting together the photomultiplier with a fluorescent screen and using strong polonium sources, Blau and Dreyfus had in fact described the first electrically modified scintillation counter. In the scientific literature there was no other previous reference to such a device for the detection of radioactive emissions.[8] During the war Samuel Curran and W. Baker had assembled a detector of alpha particles using a photomultiplier but their report was classified as part of the Manhattan Project and in collaboration with the Radiation Laboratory in California. Although issued in November 17, 1944, it was not published until February 1948.[9] Certainly unaware of the previous detector, Blau and Dreyfus were the first to describe the method in the open literature. Used primarily as a detector of alpha particles, however, the multiplier

[7] Blau and Dreyfus, "The Multiplier Photo-Tube," (1945), p. 246, 248.
[8] Perlmutter, "Marietta Blau's Work," (unpublished manuscript), p. 2.
[9] Curran and Baker, "Photoelectric Alpha-particle Detector," (1948), p. 116; Curran and Baker, A photoelectric Alpha-Particle Detector, U.S. Atomic Energy Commission Rpt. MDDC 1296, 17 November 1944, declassified 23 September 1947. See also Galison, *Image and Logic,* (1997), p. 455; Perlmutter, "Marietta Blau's Work," (unpublished manuscript), p. 2; Rheinberger, "Putting Isotopes to Work," (1999), p. 7.

photo-tube was not limited to alpha or beta measurements, as the authors argued. "In a later article we will describe its application to the measurements of strong neutrino sources."[10]

Instead of exploring the capacities of her new device, Blau was forced to shift her research in another direction. Working for competitive industrial corporations in the 1940s was not quite the same as doing research in the welcoming Radium Institute in the early 1920s. More precisely, the corporations that Blau worked from 1944 to 1948 were deeply involved in the manufacture of nuclear weapons, the commerce of uranium and radium, and the industrial uses of radium.[11] Under the pressure of producing industrial devices Blau never published her promised work on the measurements of neutrino sources. Her next article, written in 1946 and co-authored by I. Feuer, was on the production of radioactive light sources.[12] In the beginning of 1948 Blau moved to the Gibbs Manufacturing and Research Corporation and with R. Carlin she published on the industrial applications of radioactivity. A number of radioactive devices serving as resistors, electrostatic voltmeters, leveling systems, and micrometers took up Blau's creative time. It is not by chance that they were advertised as "representative examples of the forerunners of a wide range of industrial applications."[13]

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[10] Blau and Dreyfus, "The Multiplier Photo-Tube," (1945), p. 248.

[11] The Energy Employees Illness Compensation Act of 2000 ("Act" Public Law 106-398) signed by president Bill Clinton in December 7, 2000, established a program to provide compensation to individuals who developed illnesses as a result of their employment in nuclear weapons production. The two corporations that Blau worked between 1944 and 1948, The International Rare Metals Refinery Inc. and the Canadian Radium and Uranium Corporation, both in Mount Kisco, an hour outside New York, are included in the long list of covered facilities (Department of Energy 6450-010p). The Canadian Radium and Uranium Corp. was founded in 1943 and collected radium from airplane industries and watch dials (Hughes, B. "U.S. Begins Compensating Workers Exposed to Toxic Substances," *The Journal News*, August 20, 2001). Boris Pregel and his brother Alexander, Russian bourgeois who lived in Paris, came to New York in the early 1940s and established the company as one of the main uranium providers. Alexander was the administrative vice-president and both brothers looked after refugees scientists after the Second World War. Elisabeth Rona worked for them as well (all the information related to the Canadian Radium and Uranium comes from my personal communication to Vilma Hunt, retired professor of Environmental Health at Harvard School of Public Health. Her information is based on extended interviews with the Pregels).

[12] Blau and Feuer, "Radioactive Light Sources," (1946), pp. 576-580. Blau and Feuer constructed a device for using the fluorescent effect of radioactive radiation and especially that of the highly ionizing alpha radiation as a light source. Blau's contributions were based on Karlik's 1933 paper and the use of photocell, this time for transforming the alpha particles into light. The application of the radioactive light sources was enormous. For example, they were used for the standardization of the color of luminous compounds for television purposes. Also, they were utilized as a source of light for instruments previously painted with luminous compounds dangerously mixed with radioactive material (see for example the case of radium dial painters and the use of radium paint in dials of watches and instruments. Rentetzi, "The Women Radium Dial Painters as Experimental Subjects" forthcoming)

[13] Blau and Carlin, "Industrial Applications of Radioactivity," (1948), p. 82.

In her effort to find a decent research position Blau moved again within the next few months, this time to the Canadian Radium and Uranium Corporation. Her research experience at Holzknecht's Radiological Institute in Vienna in the early 1920s was now put to use. Carrying over her knowledge in medical physics to the Radium Corporation, Blau designed a photomultiplier scintillation counter for medical use. In a paper published in 1948 and co-authored with J. Smith, she argued that "with the increased availability of radioactive isotopes for medical, biological and industrial research, the problem of suitable instrumentation, and consequently units of measurement, has presented itself. There is the need for a practical and rugged instrument for routine measurements covering a wide unit in which to express beta radiation."[14] Designed for "persons not very familiar with radioactive measurements" Blau's scintillation counter was a convenient and practical instrument for wide use in hospitals and medical laboratories. Despite the fact that she was the first to design and suggest medical applications of the photomultiplier scintillation counter, Blau remained peripheral and isolated in the competitive world of industrial physics.

Already a year earlier, the efforts to design scintillation counters by replacing the human agent with a reliable and efficient photomultiplier were at their peak. J. Coltman and Fitz-Hugh Marschall from the Westinghouse Research Laboratories described a photomultiplier scintillation counter for detecting and measuring alpha, beta, and gamma rays, and high-energy electrons and neutrons. Kuan Han Sun from the same lab proceeded Blau in extending the detector to neutron measurement.[15] Shortly after, Hartmunt Kallman from the Kaiser Wilhelm Institute for Physical Research in Berlin and his student Immanuel Broser greatly advanced the technique by using naphthalene as a fluorescent screen.[16] Kallmann's expertise on the photomultiplier scintillation counters worked as a passport to the United States. In 1948 he moved to the U.S. Army Signal Corps Laboratory in Belmar, New Jersey, as a research fellow. In 1949 he was appointed director of the Radiation and Solid State Laboratory at New York University's Physics Department.[17] The zenith of the photomultiplier era came with Kallmann's student Robert Hofstadter, who left

[14] Blau and Smith, "Beta-ray Measurements and Units," (1948), p. 67.
[15] Marshall and Coltman, "The Photo-Multiplier Radiation Detector," (1947), p. 528.
[16] Broser and Kallmann, "Über die Anregung," (1947), 439-440; Broser and Kallamn, "Über den Elementarprozess," (1947), p. 642-650. The sensitivity of naphthalene, the first organic and large volume scintillator, made Kallman's counter more efficient than the previous ones.
[17] Rheinberger, "Putting Isotopes to Work," (1999), p. 8; Perlmutter, "Marietta Blau's Work," (unpublished manuscript).

Princeton University to work with Kallmann in New York. As Perlmutter points out, "the development of scintillation counters by Robert Hofstadter were critical components of his experiments on the scattering of (then) high energy electrons (600ev) from heavy protons and heavy nuclei during the 1950's, for which he received a Nobel Prize for Physics in 1961."[18]

By the end of the 1940s Blau had already lost her chance to play a central role in the uses and applications of the scintillation counter. When she finally moved to the Brookhaven National Laboratory in 1950, she had restricted access to the high energy physics facilities. Soon, she found herself out of any cooperating group. As she remained faithful to the experimental tradition of the 1930s and nostalgic for her work in Meyer's Institute, Blau was unable to continue her research in the new settings. Once again Einstein took the initiative to help her. In a letter of January 5, 1954, he reminded Samuel Goudsmit, director of the lab, "It is well known that Marietta Blau has shown really original achievements. However, it would be very unfortunate if such a personality would condemned to inactivity due to the shortage of scientific tools...Of course, Marietta Blau does not know about this letter."[19] Goudsmit's response left no doubt that the days of independent work were already past:

> The difficulties encountered by Dr. Marietta Blau can easily be formulated but are hard to solve. Physics has changed so drastically from the days of the simple experimentation that group work has become an unfortunate necessity. Miss Blau's temperament is not adapted to the type of regimentation, which occurs nowadays when only intense cooperations make it possible to obtain meager results from a tremendously expensive piece of apparatus.[20]

It was then and there that Blau was marginalized. Additionally Blau's case encourages a hypothesis. It was probably then and there that women's role shifted from active experimenters to scanners, calculators, and assistants.[21] After all, the advantage of Kallmann, Broser, and Hofstadter over Blau was their privileged positions in prestigious research universities and centers instead of industrial laboratories. For Kallmann and his research students the shift from small to big science and the growth of large-scale research came smoothly, giving them a chance to adjust to the new status of physics research. With the war over, scintillation

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[18] Perlmutter, "Marietta Blau's Work" (unpublished manuscript).
[19] Einstein to Goudsmit, 5 January 1954, AEA.
[20] Goudsmit to Einstein, 11 February 1954, AEA.
[21] See Galison, *Image and Logic,* (1997), pp. 199-200.

counters turned to a powerful instrument in a number of different disciplines. The new technology was essential for high-energy physics research, weapons control and guidance systems, for civilian mass communication, and medicine.[22] In 1949 portable scintillation counters were developed for fieldwork in geology and the detection of uranium and radium ores.[23] As Hans-Jörg Rheinberger has shown, the production of the liquid scintillation counter in 1953 "opened new epistemic dimensions for radioactive experimentation in biology and medicine."[24] In the 1970s the instrument was finally transformed into a generic technology in molecular biology and medical laboratories. Interestingly, a report issued by the Human Resources Development in Canada in 2000, concerning the medical radiation technologists, shows that 81% of the personnel who operates scintillation counters and other kinds of radiation detection equipment are women.[25]

[22] Rheinberger, "Putting Isotopes to Work," (1999), p. 7; Galison, *Image and Logic,* (1997), pp. 454-63; Mayneord and Belcher, "Scintillation Counting and its Medical Applications," (1950), p. 259.
[23] Pringle, "The Scintillation Counter," (1950), pp. 11-14.
[24] Rheinberger, "Putting Isotopes to Work," (1999), p. 2.
[25] Medical Radiation Technologists, website http://www11.hrdc-drhc.gc.ca/jobfutures/noc/3215.html (last checked 8/28/2002).

CONCLUSION

My initial aim in this study was to explore what it could mean to be a physicist in the early 20th century Vienna. Throughout this work I have focused particularly on the women experimenters who specialized in radioactivity research and played a key role in the Radium Institute from 1910 to 1938. The thorniest historical difficulty was to account for the exceptional constellation of different factors that contributed to women's unique position as active experimenters instead of technicians and members of laboratory support staff at the Radium Institute. This in turn meant understanding the complexity of what it meant to be a woman experimenter in the specific context of the Viennese physics community. Simply, it meant understanding the ways this meaning shifted over time, taking account a number of contingencies that draw attention to the Institute as a unique and enigmatic case in history of physics.

Three main threads structure this study. One is the role of the civic culture of Vienna and the spatial arrangements specific to the *Mediziner-Viertel* in establishing the context of the intellectual work of the physicists. A second concerns the ways the Institute's architecture helped to define the scientific activity in its laboratories and to establish the gendered identities of the physicists it housed. The third examines how the social conditions of the Institute influenced the deployment of instrumentation and experimental procedures especially during the Cambridge-Vienna controversy of the 1920s. These threads are unified by their relation to the changing political context during the three contrasting periods in which the story unfolds. From the feminist petitions for women's admission to university studies at the end of the 19th century and the rising of Social Democrats before the end of the First World War to Red Vienna and finally to the *Anschluss,* politics structured the open-ended process through which women negotiated their world. During that time the organization of scientific practice as a gendered enterprise was deeply affected by socioeconomic and political conditions. It is in this context I attempted to reconstruct women's lived experiences in the setting of the Radium Institute. As I show, the careers of the Institute's women were shaped in good part by the shifting meanings, and the politics, that attached to being a "woman experimenter" in Vienna from 1910 to the beginning of the Second World War.

In *fin-de-siècle* Vienna, before the Institute was established, physicists with interest in the emerging field of radioactivity were public figures with a less clear-cut disciplinary identity, carrying scientific discourse outside of their inadequate laboratories into the cultural and everyday life of the city. Certainly Vienna was not like any other city at the time. Exner, for instance, left Strassburg disappointed by the monolithic culture of its physics community and returned to Vienna, a city of unique intellectual life and creativity. Physicists like Exner succeeded in institutionalizing radioactivity within the context of the Viennese high culture. During the 1910s with the support of the Austrian Academy of Sciences and that of the industrialist Carl Kupelweiser, physicists working on radioactivity established their disciplinary identities by building the Institute as a specialized center in radium research. In the international scientific community they underscored their identities as radium merchants and presented themselves as serious scientific competitors. At the same time the nature of radioactivity as an interdisciplinary field reinforced their feeling of belonging to an extended scientific community. The Viennese physicists attended the meetings of physicians, lectured to pharmaceutical students, and worked closely with chemists on the investigation of physical and chemical identities of radioactive elements.

From the Radium Institute's earliest days the making of the physicists' professional identities as specialists in radioactivity was strongly tied with the locality of the institutions they interacted with. The University of Vienna, the Radium Institute, the Physics and Chemistry Institutes, and a number of medical institutions were all located in the *Mediziner-Viertel*, a space with abstract cultural and epistemic boundaries and concrete, physical edifices that materialized those boundaries. Thinking about identity formation, I emphasized the fact that in the Institute's earliest days the majority of the physicists were men, with women entering the scientific scene as students and advisees. By the end of the First World War, nonetheless, women managed to form their professional identities as specialists on radioactivity and were able to move back and forth between the Radium Institute and the medical institutions of the city. For example, after finishing her studies in physics and her *Praktikum* at the Institute, Blau had a short career in medical industry. In general, the women in my narrative with the support of some of their male colleagues, modestly and slowly, integrated themselves into the community of radioactivity researchers.

Persistently, they claimed positions within the Institute. For example. in 1920, after working for a year as an unpaid *Assistentin,* Fonovits was finally hired at the Institute.

The location of the Institute in the center of cultural and epistemic life of Vienna, the *Mediziner-Viertel,* worked in women's favor. In one sense, the few women in science became visible in the relatively small scientific community of Vienna. Several times a day, women crossed Währingerstrasse in order to attend classes and participate in laboratory courses. The face-to-face interactions in the *Mediziner-Viertel* affected their social lives and contributed to their visibility in the community. For example, it was not hard for Meitner to recall that Horovitz had been a chemistry student when Hönigschmidt asked her to suggest a possible collaborator to him. Although few in absolute numbers, the women who entered the Institute during its first decade were surprisingly numerous considering that the University of Vienna had admitted them less than two decades ago. In another sense, the crossing of Währingerstrasse facilitated the crossing of disciplinary boundaries as well. From physics to medicine and chemistry to physics women transferred their knowledge among disciplines, shifting and shaping the boundaries of radioactivity at the same time.

Thus, I argue that the natural space for tracing the formation of the disciplinary identities of the physicists who worked at the Radium Institute is the city. As a context of intellectual work, the city, and especially the *Mediziner-Viertel,* is linked to physicists' self-images and their interdisciplinary practices. The urban reconstruction of the city becomes sociologically interesting for it provides the space to study the social and political negotiations that shaped scientific institutions in a concrete sense. Implementation of the decision to move from the ramshackle Physics Institute in Türkenstrasse to the new natural science quarter across from the *Josephinum* took physicists more than three decades. Moreover, it involved endless negotiations on the nature of their discipline, the exact location of their institutes in relation to their professional practices, and the identities they wanted to portray through the architecture of their buildings.

Indeed, the architecture of the Radium Institute materialized the identities that the physicists working on radioactivity wished to acquire. On the one hand, the design of the Radium Institute as a separate building from the Physics and Chemistry Institute legitimized the research on radioelements as a scientific specialty, which, however, was deeply depended on physics and chemistry. The new building provided and stabilized professional identities for those physicists whose new disciplinary identities were in risk of blending with well-established ones. For the women who worked at the Institute obtaining distinct identities as specialists in a new field opened up new vocational opportunities and helped to maintain their positions as experimenters. On the other hand, the internal spatial arrangements of the Institute reflected the ways through which the architecture of the laboratory acknowledged that physicists were gendered. The separate sanitary installations for men and women indicated the existence of women in the Institute. Moreover, by having a laboratory of their own, women gained a sense of belonging. They were no longer transients in the field.

A decade after its opening, the building of the Institute, although externally unchanged, had undergone several internal transformations. By welcoming different researchers with diverse research projects, the laboratory space had been reassigned and the material basis for experimental work had changed dramatically. During the 1920s scintillation counters, Shimizu-Wilson ray track apparatus, photographic emulsions, and powerful microscopes become part of the material culture of the Radium Institute. After Pettersson's arrival in Vienna, polonium sources, spent radon needles from the neighboring hospitals, and photographic plates laid around the workbenches and occupied the interest of the experimenters.

The patterns of experimentation were transformed as well. Although several researchers worked closely together before the 1920s, those groups were limited to two people. For instance, Hönigschmid teamed up with Horovitz, Ludwig Flamm worked with Mache, and Hess with Lawson. With Pettersson's arrival the groups grew appreciably and complicated the patterns of collaboration. "Our particular kind of work," Pettersson argued in 1928, "requires the close and continued collaboration of at least a dozen highly specialized people."[1] At the same time Przibram gathered around him a number of students occasionally drawing experienced researchers from Pettersson's team. Karlik and Kara-Michailova, for example, often shifted to Przibram's research projects and co-authored papers with him.

New patterns of experimentation fostered new types of work relationships. Women working in Pettersson's group formed close and deep friendships. Blau, Karlik, Kara-Michailova, and Rona preserved those, even when each of them was on

[1]Hans Pettersson's report to the International Education Board, April 1928, AUG.

a different continent. I do not argue, however, that women acquired an essential quality for developing close friendships with other women. Obviously they benefited from the fact that as single women they had a flexible time schedule that permitted them to spend long days in the Institute, working over the same experiments and sharing common research questions. At the same time their ties with Pettersson and his wife grew stronger as they developed into experienced experimenters. Karlik remained Pettersson's close friend, a family acquaintance, and an invaluable collaborator even after Pettersson left Vienna in the early 1930s.

Given the importance of the experimental work done at the Institute and the flow of research money, women were able to travel to other European institutes in order to get training in new experimental techniques. For instance, Rona spent a few weeks at Curie's institute in Paris, learning how to prepare polonium sources. In general the flow of money and thus the prominent scientific investigations that took place at the Vienna Institute boosted physicists' prestige and led the Institute to the forefront of radioactivity research. Blau and Wambacher exchanged lengthy correspondence with Heisenberg after their golden event in emulsions. Over all during the 1920s instead of being inexperienced students, the women at the Institute established their professional identities as experimenters with deep knowledge in constructing and manipulating most of the instruments in use. In some of the collaborations they formed, women acted as primary investigators and mentors to younger students and colleagues. For example Rona introduced Ewald Schmidt to the preparation of polonium sources and, in the beginning of their collaboration, Blau worked with the young Wambacher as her advisor.

In discussing the history of the scintillation counter, I emphasized that the social and cultural setting of the Radium Institute defined the ways the counters were used in Vienna. In the eyes of their colleagues Kara-Michailova, Rona, and Blau were not merely counters of scintillation flashes. They were deeply involved to the design, production, and evaluation of experimental results. Given the economic difficulties of their research group it is not surprising that the women insisted in saving the technique. But its is likely that their main objective was to maintain their unique status in the Institute through the preservation of the scintillation counter. Clearly the instrument embodied the women's self-images as productive members of the group and secured their professional identities as experimenters.

How much of the above could have happened without a political background that favored innovative research and novel gender relations? As I have argued throughout this study, the social democratic discourse offered a conceptual framework favorable to radical educational and social reforms. Women entered the University of Vienna and the physics institutes in numbers far different from those in other Austrian cities. Within the political context of Social Democracy the process of attributing meaning to sexual difference and of constructing relationships of power between women and men provided space for women's intellectual development. Additionally, Meyer's connections to such Social Democrats as Julius Tandler, enabled interdisciplinary crossings to the institute's personnel. Meyer's own personality, charismatic leadership, and openmindedness secured women's fair share of the Institute's research agenda. The fact that the Institute was privately funded and based on soft money, although it was supported by the Academy as well, gave Meyer more flexibility for internal hiring. Nevertheless, as the gender hierarchies did not change at the University of Vienna or the Austrian Academy of Sciences, women struggled to get permanent positions and have access to the system of higher education as professors.

The fact that the Institute was a piece of Vienna's political history became more obvious during the 1930s. When the fascists seized power in Vienna in 1933, they deliberately put an end to most of the progressive forces of Viennese society. Social Democrats, feminists, and Jews became the targets of a hate campaign and totalitarian politics. As reflected in the number of women enrolled at the University of Vienna, in liberal institutes, and in the scientific societies of the city, the authoritarian regime imposed its own ideology in place of the social democratic one. The parallel decline in experimentation at the Institute made this situation even more difficult. The resolution of the Vienna-Cambridge controversy led to the destruction of the research agenda of the Institute, the disbanding of the working groups, and the departure of Pettersson, the most influential figure during the 1920s. The dramatic economical conditions of the Institute and the country in general left no opportunity for restructuring scientific research in the radioactivity laboratory.

Incidents like these are interrelated and complex enough that no single perspective could capture them. Each is part of a puzzle that can not be accessed except against the background of the whole picture. For instance, a reconstruction of the story that argues for a total collapse and negative outcome of the experimental enterprise of the 1920s fails on several accounts. On a first level, most of the women members of Pettersson's group dispersed throughout the most prestigious institutes of Europe using, the experience, fame, and knowledge they acquired while working with Pettersson. On a second level, many of the same women became pioneers in establishing research in the trading zone of physics and oceanography, using the experimental skills and knowledge they had gained from radioactivity research. Pettersson was once again instrumental in securing funding and welcoming women into his newly established oceanographic institute in Göteborg and in the station at Bornö. Last, the disciplinary crossing resulted in the establishment of a formal collaboration between the institutions in Sweden and the Radium Institute in Vienna. The network of collaboration worked both ways, benefiting not only women scientists from Vienna, but also Pettersson's assistant, the Swede named Börje Kullenberg, who spent a year at the Vienna Institute in 1938/39. Thus as experimenters specialized in radioactivity women reached further than the Vienna Institute and entered European scientific networks.

The end of the 1930s brought the nadir of the Institute with its nazification and the enforced exile of Jewish personnel. The laboratory ethos that governed collaborations since 1910 was destroyed. The women who stayed at the Institute after 1938 represented a broad spectrum of beliefs. Karlik attempted to continue her work undisturbed and hoped to be in a better position to help those of her colleagues who needed support. Wambacher was a Nazi, whatever this might have meant for her. The confiscation of Blau's work by Wambacher and her friends was one of a series of examples that marked the ongoing decline of the Institute. Under that strenuous political time some of the Jewish women fled Austria in search of professional careers in safer environments. It is not an exaggeration, as Blau's later career demonstrated, that it was there and then that the Institute's women were pushed to the margins of physics. Losing their research status and forced to separate from friends and relatives while changing their everyday life patterns, the women were in a disadvantaged position. Parallel changes in instrumentation and experimentation, as Galison illustrates in *Image and Logic*, led the new generation of women physicists to performing auxiliary tasks in the world of nuclear and particle physics.

To analyze the complexity of those cases is not enough to focus on gender as the distinct factor in this historical narrative. In my study I used gender particularly to refer to two intertwined aspects of a social process that are always co-produced and are specific to the historical and cultural setting in which it is taking place. First, gender names the process of attributing meaning to sexual difference as a result of the dominant discourse of the time. Second, it names the process of constructing power relations based on sexual difference. However, the shift from the discourse that names what is a man and a woman in particular historical and cultural contexts to the embodiment of these meanings and power relations is what makes every historical setting unique and so too the concept of gender depending on it. The ways specific individuals live out structures of power and discursive constructions of sexual difference allow for variations among them. My analysis suggests that "women" and "men" in Vienna in the first half of the 20th century were not the same as elsewhere. To grasp the meaning of a woman experimenter in Vienna I relied on the concept of lived experiences. In other words, I relied not on gender or race as the sum of those distinct social processes relevant to the case of the women of the Institute but on the complex, ongoing process of becoming a woman in that specific historical context.

Gender, nonetheless, remains an important analytical tool and its use opens up areas for epistemological and sociological inquiry. Throughout this work gender functions as both an epistemological and methodological concept. It is epistemological in that by employing it in a specific historical case one can grasp for example hidden aspects of experimentation in radiation physics. Focusing on the material culture of the laboratory and specifically on the use of the scintillation counter, I argued that instruments serve as means of showing how gender assumptions penetrate the experimental process. Technologies such as x-ray photographic films and photographic plates of emulsions, all tabletop, portable, and cheap apparatuses easy to design, use, and transport, become pathways for revealing what role gender played in the production of scientific knowledge in the early 20th century Vienna. Simultaneously, gender serves as a methodological apparatus which triggers questions concerning the kind of social formations in Viennese culture and within the Institute that allowed women to be accepted into the culture of radiophysics. By using gender in this way, I paid attention to the politics of collaboration among the practitioners, the gendering of tasks, and the gender hierarchies constructed in the Institute. However, a woman is never simply sex or simply gender. To talk about individual women of the Institute I shifted to the ways they encompassed experiences of all kinds of situations, and their sexed bodies were among them. In this context, the history of what it meant to be a woman experimenter in radioactivity and nuclear physics in Vienna has been inseparable from the country's social and political history, as it has been part of the history of the discipline.

ABBREVIATIONS FOR ARCHIVAL SOURCES

AAUW	American Association of University Women
AEA	Albert Einstein Archives, The Jewish National and University Library, The Hebrew University of Jerusalem.
AGMPG	Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin
AHL	Archive of the Hospital in Lainz, Vienna (not-catalogued)
AIP	American Institute of Physics, College Park, Maryland
AÖAW	Archiv der Österreichische Akademie der Wissenschaften
AUW	Archiv der Universität Wien
BHL	Bentley Historical Library, University of Michigan
CDICAM	Centro de Documentation e Investigacion de la Comunidad Ashkenazi de Mexico, Mexico City
CUL	Cambridge University Library
E.S.I.M.E.	Escuela Superior de Ingeniería Mecánica y Eléctrica
GDSCA	Grenander Department of Special Collections and Archives University at Albany, State University of New York
GUB	Göteborgs Universitetsbibliotek, Sweden
IAWA	International Archive of Women in Architecture, Virginia Tech
MTNR	Lise Meitner Collection, Churchill Archives Center, Churchill College, Cambridge
NBA	Niels Bohr Archive, Copenhagen
RAC	Rockefeller Archive Center, North Tarrytown, New York
RR	Rose Rand Collection, Archives of Scientific Philosophy, Hillman Library, University of Pittsburgh

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APPENDIX:

TERMINOLOGY OF THE DECAY CHAINS OF THE RADIUM SERIES

The Uranium Series

Radioelement	*Corresponding Element*	*Symbol*	*Radiation*	*Half-Life*
Uranium I	Uranium	^{238}U	α	4.51×10^9 yr
Uranium X_1	Thorium	^{234}Th	β	24.1 days
Uranium X_2*	Protactinium	^{234}Pa	β	1.18 min
Uranium II	Uranium	^{234}U	α	2.48×10^5 yr
Ionium	Thorium	^{230}Th	α	8.0×10^4 yr
Radium	Radium	^{226}Ra	α	1.62×10^3 yr
Ra Emanation	Radon	^{222}Rn	α	3.82 days
Radium A (99.98% | 0.02%)	Polonium	^{218}Po	α and β	3.05 min
Radium B	Lead	^{214}Pb	β	26.8 min
Astatine-218	Astatine	^{218}At	α	2 sec
Radium C (99.96% | 0.04%)	Bismuth	^{214}Bi	β and α	19.7 min
Radium C′	Polonium	^{214}Po	α	1.6×10^{-4} sec
Radium C″	Thallium	^{210}Tl	β	1.32 min
Radium D	Lead	^{210}Pb	β	19.4 yr
Radium E ($\sim$100% | 2×10^{-4}%)	Bismuth	^{210}Bi	β and α	5.0 days
Radium F	Polonium	^{210}Po	α	138.4 days
Thallium-206	Thallium	^{206}Tl	β	4.20 min
Radium G (End Product)	Lead	^{206}Pb	Stable	—

The Actinium Series

Radioelement	*Corresponding Element*	*Symbol*	*Radiation*	*Half-Life*
Actinouranium ↓	Uranium	^{235}U	α	7.13×10^{8} yr
Uranium Y ↓	Thorium	^{231}Th	β	25.6 hr
Protactinium ↓	Protactinium	^{231}Pa	α	3.43×10^{4} yr
Actinium (98.8% → Radioactinium; 1.2% → Actinium K)	Actinium	^{227}Ac	β and α	21.8 yr
Radioactinium	Thorium	^{227}Th	α	18.4 days
Actinium K	Francium	^{223}Fr	β	21 min
↓ Actinium X ↓	Radium	^{223}Ra	α	11.7 days
Ac Emanation ↓	Radon	^{219}Rn	α	3.92 sec
Actinium A ($\sim$100% → Actinium B; $\sim 5 \times 10^{-4}$% → Astatine-215)	Polonium	^{215}Po	α and β	1.83×10^{-3} sec
Actinium B	Lead	^{211}Pb	β	36.1 min
Astatine-215	Astatine	^{215}At	α	$\sim 10^{-4}$ sec
↓ Actinium C (99.7% → Actinium C″; 0.3% → Actinium C′)	Bismuth	^{211}Bi	α and β	2.16 min
Actinium C′	Polonium	^{211}Po	α	0.52 sec
Actinium C″	Thallium	^{207}Tl	β	4.8 min
↓ Actinium D (End Product)	Lead	^{207}Pb	Stable	—

The Thorium Series

Radioelement	*Corresponding Element*	*Symbol*	*Radiation*	*Half-Life*
Thorium ↓	Thorium	^{232}Th	α	1.39×10^{10} yr
Mesothorium I ↓	Radium	^{228}Ra	β	6.7 yr
Mesothorium II ↓	Actinium	^{228}Ac	β	6.13 hr
Radiothorium ↓	Thorium	^{228}Th	α	1.91 yr
Thorium X ↓	Radium	^{224}Ra	α	3.64 days
Th Emanation ↓	Radon	^{220}Rn	α	52 sec
Thorium A ↓	Polonium	^{216}Po	α	0.16 sec
Thorium B ↓	Lead	^{212}Pb	β	10.6 hr
Thorium C (66.3% → Thorium C′; 33.7% → Thorium C″)	Bismuth	^{212}Bi	β and α	60.5 min
Thorium C′ ↓	Polonium	^{212}Po	α	3×10^{-7} sec
Thorium C″ ↓	Thallium	^{208}Tl	β	3.1 min
Thorium D (End Product)	Lead	^{208}Pb	Stable	—

CURRICULUM VITAE

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PERSONAL:

Born on March 30, 1969
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EDUCATION:

Doctoral Student in the Science and Technology Studies Program, **Virginia Polytechnic Institute and State University**, Blacksburg, VA, since August 1997. Degree expected, May 2003.

Dissertation Title: Gender, Politics, and Radioactivity Research in Vienna, 1910-1938.
Advisor: Richard Burian. Committee members: Gary Downey, Bernice Hausman, Joseph Pitt. External committee members: Aristides Baltas (National Technical University of Athens), Peter Galison (Harvard University).

Master of Arts in Philosophy, **Virginia Polytechnic Institute and State University,** Blacksburg, VA, August 1998- May 2002.

Master of Arts in History and Philosophy of Science and Technology, **National Technical University of Athens**, Greece, September 1994 - July 1996.

Thesis Title: The Role of Gender Metaphors in Physics: The Case of a 19^{th} Century Greek, Physics Textbook (in Greek).
Advisor: Kostas Gavroglou. I was also greatly benefited from the help of Aristides Baltas, National Technical University of Athens (NTUA) and Peter Machamer, Department of History and Philosophy of Science, University of Pittsburgh.

Certificate from the European Summer School in Women's Studies, **University of Utrecht,** The Netherlands, summer 1996.

Bachelor of Science in Physics, **Aristotelian University of Thessaloniki**, Greece, September 1986 - June 1991.

Thesis Title: Issues of Gender and Science in the Scientific Revolution
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RESEARCH EXPERIENCE:

- **FELLOWSHIPS:**

Postdoctoral Fellow, **Max Planck Institute for the History of Science**, Berlin, Germany, May 15, 2003-December 31, 2003.

I will work with Dr. Ursula Klein in her research project entitled “History and Philosophy of Laboratory Sciences: Between the Laboratory, the Workshop and the Field.”

Research Fellow, **Konrad Lorenz Institute for Evolution and Cognition Research,** Vienna, Austria, October 2001-December 2001.

I explored the scientific, cultural, and political interrelations between the Institute for Radium Research and the biological institute known as the *Vivarium.* The project concerned the politics of collaboration in the intersection of radioactivity and biology from 1920 to 1938.

Research Fellow, **Institute for Advanced Studies on Science, Technology and Society**, Graz, October 2000-September 2001.

I conducted archival research related to my dissertation topic.

State Fellow, **State Scholarship Foundation Prize** (IKY), Greece, September 1994 – August 1996.

- **RESEARCH TRAVEL GRANTS:**

Graduate Research Development Program, **Graduate Student Assembly, Virginia Polytechnic Institute and State University,** March 2002.

- archival research at the Austrian Academy of Sciences, Vienna.

Research Grant, **Max Planck Institute for the History of Science**, Berlin, Germany, December 2001.

- archival research at the Max Planck Society, Berlin.

Research Grant, **Institute for Advanced Studies in Science, Technology and Society**, Graz, Austria, September 2001.

- archival research at the University of Göteborg
- interview with Agnes Rodhe, daughter of Hans Pettersson central figure at the Institute for Radium Research in the 1920s.
- interview with Artur Svansson, oceanographer with a special interest on Hans Pettersson and the biographer of Otto Pettersson, Hans’ father.

Grant-in-aid, **American Institute of Physics**, USA, 1999.

- archival research at the ESIME and UNAM in Mexico City, Mexico.

- interview with one of Marietta Blau's students in Mexico. Blau worked at the Institute of Radium Research during the 1920s and 1930s.
- archival research at the University of Miami, Florida.
- interview with Arnold Perlmutter, colleague of Marietta Blau.
- interview with Leopold Halpern, a close friend of Marietta Blau.

Graduate Research Development Program, **Graduate Student Assembly, Virginia Polytechnic Institute and State University,** March 1999.

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ARCHIVAL RESEARCH:

I conducted research in the following archives:

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University of Miami, Florida, the University Archives
University of Pittsburgh, Hillman Library, Rose Rand Collection
Mexico, Mexico City
Jewish Archives
The archives of the Escuela Superior de Ingenieria Mecanica y Electrica (ESIME)
The archives of the Universidad National Autonoma de Mexico (UNAM)
England, Cambridge
University of Cambridge Archives
Churchill College Archives
Austria, Vienna
The Archives of the Austrian Academy of Sciences
University of Vienna Archives
Archives at the Hospital in Lainz
The Archives of the Physics Department of the University of Vienna
Sweden, Göteborg
Archives of the University of Göteborg
Germany , Berlin
Archives of the Max Planck Gesellschaft

TRAVEL GRANTS FOR CONFERENCE PRESENTATIONS:

- University of Illinois, Illinois Program for Research in the Humanities
- Society for the History of Technology
- Joint Atlantic Seminar on the History of Physical Sciences
- Virginia Tech, STS Program

- International Union of the History of Science, Division of History of Science, Scientific Instrument Commission
- Institut für Medizin- und Wissenschaftsgeschichte, Medizinische Universität, Lübeck, Germany

CONFERENCE AND WORKSHOP PRESENTATIONS (given and scheduled):

9/13-14/2003	"The History of Women in Radioactivity Research, Vienna, 1910-1938" **Women's History Network**, University of Aberdeen, Scotland
7/16-20/2003	"The Thwarting of a Promising Proposal: A Joint Laboratory Between the Institute for Radium Research and the *Vivarium* in Vienna" **International Society for the History, Philosophy, and Social Studies of Biology (ISHPSSB),** Vienna, Austria
6/8-11/2003	"Women Physicists in the Institute for Radium Research in Vienna, 1910-1938" **International Conference: Women Scholars and Institutions,** Commission Women in Science of the IUHPD/DHS, Prague, Czech Republic (I organize a panel on Women in Radioactivity Research)
3/6-8/2003	"The Spatial Culture of Physics and its Gender Dimensions: The Institute for Radium Research in Vienna, 1920-1938" **Spaces of Exploration, Third Conference on Laboratory History**, Champaign-Urbana, Illinois
1/31/2003	"Gender, the Urban Setting and the Architectural Design of the Institute for Radium Research" **STS Friday Seminar,** Virginia Tech, Blacksburg
10/17-20/2003	"Women and Technology in Radioactivity Research, 1920-1938." **Society for the History of Technology** (SHOT), Toronto, Canada
9/21-22/2002	"The Spatial Culture of Physics." **Joint Atlantic Seminar on the History of Physical Sciences** (JASHOPS), Georgia Tech, Atlanta
9/9-14/2002	"Designing their Own Instruments: Women as Designers Rather than Merely Users of Apparatuses on Radioactivity Research from 1920 to 1938." **XXI Scientific Instrument Symposium, International Union of the History and Philosophy of Science, Scientific Instrument Commission,** Athens, Greece
3/22-24/2002	"The Spatial Culture of Physics and its Gender Dimensions" Conference entitled Transforming Spaces, **Graduiertenkolleg Technisierung und Gesellschaft,** Technische Universität Darmstadt, Germany
3/17-19/2002	"The Gendered Production of Knowledge at the Institute for Radium Research, 1920-1938." **Mephistos, Graduate Students Conference**, Virginia Tech, Blacksburg
12/10/2001	"Feminist Epistemology: How a Case Study from History of Physics Undermines Harding's Standpoint Theory" Workshop on STS, **Institute for Advanced Studies on Science, Technology and Society,** Graz, Austria
12/6/2001	"The Interrelation of Radiophysics to Biology" A Brown Bag Presentation, **Konrad Lorenz Institute for Evolution and Cognition Research**, Vienna, Austria
11/17/2001	"Women Physicists at the Institute for Radium Research in Vienna, 1920-1938." Presentation at the **Historische Wissenschaftsforschung Seminar**, Vienna, Austria

5/18-20/2001	"The "Radium Girls" as Experimental Subjects" **Institut für Medizin- und Wissenschaftsgeschichte**, Conference on the History of Human Experimentation During the 20th Century, Lübeck, Germany
10/26-29/2000	"From Technological Change to Political Technology of the Body: The Case of Radium Dial Painters," **Social Science History Association Conference,** Pittsburgh

WORKSHOP AND CONFERENCE ORGANIZATION:

- Main coordinator of the "Critical Issues in Science, Technology, and Society," joint workshop, Virginia Polytechnic Institute and State University (USA); Institute for Advanced Studies on Science, Technology and Society (Graz, Austria); Inter-University Research Center for Technology, Work, and Culture (Graz, Austria). Graz, June 7-8, 2001.

- Assistant for the organization of the "Gender and Technology: Research, Revisions, Policies and Consequences," Southwester Women's Studies Association Conference organized by the Women's Studies Program at Virginia Tech, Blacksburg, March 20-22, 2003.

TEACHING AND WORK EXPERIENCE:

Graduate Teaching Assistant, **Virginia Polytechnic Institute and State University,** Blacksburg.

- Women's Studies Program, Fall 2002-Spring 2003
- Philosophy Department, Spring 2001
- Science and Technology Studies Program, Spring 2000
- Women's Studies Program, Fall 1997-Spring 1999

List of Courses Assisted

- Gender and Science
- Introduction to Women's Studies
- Humanities, Science, and Technology: An Introduction
- Elementary Logic

Resident Assistant,

- Summer Program of the New York University in Athens, Greece, 1999

Instructor, **Kantas Private School**, Athens, Greece.

- History of Science, elementary and high school level classes, 1996

Internships

- **National Technical University of Athens**, Program of Continuing Education, Athens, Greece, 1995
- **ELKEPA** (a Greek state organization for continuing education), research on alternative energy sources for local tourism, Kavala, Greece, 1992
- **Phosphoric Fertilizers Industry** (PFI), Department of Instrumentation, Kavala, Greece, 1988.

Private Tutor in Sciences, self-employed throughout my studies in Greece. I assisted high school students in physics, chemistry, and mathematics.

GUEST LECTURES:

"The Role of Gender in Science and Technology Studies" Graduate Seminar *Main Themes in STS*, MA Program in History and Philosophy of Science and Technology, National Technical University of Athens, January 17, 2000. Professor: Michalis Assimakopoulos.

"Women Physicists at the Institute for Radium Research in Vienna, 1920-1938," Graduate Seminar *Technik-Bildung und Geschlecht II*, Techniche Universität, Graz, Austria, May 12, 2001. Dr. Christine Wächter.

"Gender in the History of Science" Graduate Seminar *Main Themes in the History of Science*, Ph.D. Program in STS, Virginia Tech. October 24, 2002. Professor: Ann Laberge.

LANGUAGES:

Greek and English
Reading ability: German, French, and Spanish.

PUBLICATIONS:

Articles:

"Gender in Science and Technology: An Introduction" *Pyrforos* (in Greek, in press)

"Women Radium Dial Painters as Experimental Subjects or What Counts as Human Experimentation," *Advances in Bioethics*, (in press.)

"Marietta Blau." An encyclopedia Entry for *Jewish Women: A Comprehensive Historical Encyclopedia,* Hyman, Paula and Ofer, Dalia (eds), (Jerusalem: Shalvi Publishing Ltd., in press.)

"Feminist Epistemology: How a Case Study from History of Science Undermines Harding's Standpoint Theory" in Bammé, A., Getzinger, G.; Wieser, B. *Yearbook 2002 of the Institute for Advanced Studies on Science, Technology and Society*. pp. 103-119. Munich, Vienna: Profil.

"Women Physicists in the Institute for Radium Research in Vienna, 1920-1938: A Statistical Report," *Soziale Technik*. 2(2001):9-12.

"Beyond the Ivory Tower" *Recent Science Newsletter*, Center for History of Recent Science, The George Washington University. 3(2001): 1, 10-11. (republished by the *Science, Technology and Society Newsletter* of the Lehigh University, 130(2002): 5-7.)

"A Description and an Evaluation of an Experiment: Teaching History of Science in a Private Elementary and High School" [in Greek], *Synchrone Ekpaideusi* [*Contemporary Education*] 98(1998): 45-53.

"The Role of Teaching History of Science in High School" [in Greek], *Synchrone Ekpaideusi* [*Contemporary Education*] 94(1997): 79-82.

Book Reviews:

Ross Mullner, *Deadly Glow: The Radium Dial Worker Tragedy*, (Washington: American Public Health Association, 1999) in *Science, Technology and Human Values*, Winter 2001, 26(1): 106-8.

Peter Galison, *Image and Logic: A Material Culture of Microphysics,* (Chicago: University of Chicago Press, 1997) in *The British Journal for the History of Science*, 2000, 33 (3): 369-371.

Editorial work:

Rentetzi, Maria and Andrea Gilbert (eds.) Greek Translation of Londa Schiebinger's book *The Mind Has no Sex? Women in the Origins of Modern Science* (Cambridge, Mass.: Harvard University Press, 1989, Publisher of the Greek edition: Katoptro, forthcoming.) Rentezi, Maria. "Introduction to the Greek edition." (forthcoming)

Other Publications:

Matta, Pandora and Rentetzi, Maria. 1991. "Seeking Other Amazons for Our Utopia" [in Greek] *Gia ena Prasino Panepistimio*, [*For a Green University*] 2: 19-22.
(*For a Green University* was an alternative student journal.)

Kafka, Maria and Rentetzi, Maria. 1990. "Sexism in Science" *Katina* 5: 24-25.

Rentetzi, Maria. 1988. "Women and Army" *Katina* 3: 16-17.
(*Katina* was a feminist journal published by the autonomous feminist group *Katina* in Thessaloniki, Greece, from approximately 1985 to 1992. The women of the group were responsible for the whole publishing process starting from the collection of articles to the editing and final lay out of each issue).