

Physics Department

2006-2007 Annual Report

June 7, 2007

Part 1: Executive Summary

The Physics Department continues to grow its faculty while focusing its research programs in a few carefully selected strategic directions. To strengthen our research profile, we are beginning to recruit graduate students more aggressively. The fact that the number of graduate student applications has more than doubled over the past five years allows us to be much more selective. At the same time, our undergraduate program remains strong, and our core and service components run smoothly, thanks to a team of dedicated, experienced instructors. The faculty continue to engage in a variety of ways with the university and the broader community.

Two new faculty members – Drs. Pleimling and Link – joined us in August 2006. Dr. Pleimling was recruited as part of the computational science cluster; he adds his expertise in large-scale simulations of aging phenomena in a variety of materials to our statistical physics/complex systems group. Dr. Link joins the neutrino group and has already received DOE funding to pursue an experiment at the Daya Bay nuclear reactor in China. A search in the Spring of 2007 focused on astrophysics, a vulnerable yet critical area in the department. We are excited that Dr. Nahum Arav, currently a research scientist at the University of Colorado, Boulder, will join us in January 2008. Dr. Arav brings roughly 0.5M in funding in NSF and NASA grants to Virginia Tech, along with a well-recognized research program in active galactic nuclei, using space- and ground-based observatories. The search also attracted the application of Dr. Patrick Huber, a young neutrino phenomenologist with an outstanding track record in impact studies of large-scale neutrino experiments and a growing interest in cosmic relic neutrinos. Negotiations with Dr. Huber are still in progress; all indications are that he will agree to join us in August 2008.

In the area of learning, our undergraduate program is characterized by high academic standards, pursued in a supportive climate focused on student mentoring and co-operation. Our graduating class of 18 students was larger than in previous years. Most students opted to pursue Ph.D. programs, including such highly ranked ones as Harvard, Maryland, and Michigan. Our two valedictorians this year, My Linh Pham and Brian Skinner, are both outstanding scholars with great promise. Brian is Virginia Tech's 33rd Goldwater Scholar (and the 7th from Physics) and won an NSF Graduate Research Fellowship. Linh graduated with a straight 4.0 GPA and won so many scholarships that she exceeded the university limit. The quality of students in the graduate program is also laudable. Two are NSF Graduate Research Fellows; three others are NSF IGERT fellows; and two students won competitive College of Science awards. Three Ph.D. and six M.S. degrees were awarded this year.

In the research and discovery arena, the external funding available to the department continues to grow. Including the appropriate shares from grants on which physics faculty serve as Co-PIs, the total funding for this FY amounts to slightly over \$2.1M. This corresponds to an 11% increase over last year. Our publication activity remains high, at roughly 100 refereed articles and journal proceedings for the department as a whole. Research in physics is an extremely international enterprise, and our faculty are involved in a broad range of collaborations spanning the globe. Conference invitations ranged from North America and Asia to Europe and the Middle East. Slightly more than half the faculty are engaged in research in nanoscience, at the nano-bio interface, and in complex self-organized systems and materials, and collaborate widely with colleagues across campus. A key member of this group, Royce Zia, received a major honor this year, by being elected a Fellow of the American Physical Society (APS). The other large signature effort, neutrino physics, dominates the research programs of faculty in the particle and astrophysics domain. Faculty in this group make extensive use of large national and international experimental facilities, located on three continents, and are well represented on national planning and advisory committees in this field.

Other initiatives also contribute towards increasing the visibility of the department. More so than in previous years, faculty members are organizing workshops or conferences *here on campus*. This reporting period saw three such events: the Zallen symposium in August 2006, the LONU-LENS workshop in October 2006, and the first Sowers Workshop on Theoretical Physics in May 2007. Each event introduced prominent invited speakers as well as participants from campus and elsewhere to the department, and disseminated our findings and programs far beyond the boundaries of Blacksburg.

Alumni and development activities are expanding. This year saw our first alumni reunion – in nearly a decade – at a major national meeting. The department is very fortunate to have received a significant pledge which will establish a Senior Faculty Fellowship. A new graduate award is now fully endowed, and another one is being established, as part of a will. Mr. Mark Sowers made a major donation to support an international workshop on recent developments in string theory.

August 2006 saw a change in department leadership. Dr. Royce Zia returned to full-time teaching and research, and Dr. Beate Schmittmann began a four-year term as department chair. Her priority will be to enhance the department's research profile, while keeping our undergraduate and outreach programs as vibrant and successful as they are now. As the first female department leader in the College of Science, her appointment attracted some media interest. Two of these features also highlighted the nanoscience research programs of the three other female faculty members in the department.

Many visitors shared their impression that the department at its current stage is much stronger than its national reputation and rankings reflect. We are confident that the standard metrics will catch up with these impressions in the near future.

Highlights of our activities are included in this report. Further details and relevant links may be found on <http://www.phys.vt.edu/>.

Part 2: Academic Accomplishments

I. Learning

Undergraduate Program

Our undergraduate program continues to be very strong. Its success is due to three key components. First, the undergraduate curriculum is challenging and comprehensive. The faculty demand high-quality academic work while supporting the students as they work to cope with the demanding material. Many of our students are accepted into top graduate programs across the country and find themselves very well prepared. Second, the department emphasizes the participation of undergraduates in faculty research projects as a capstone educational experience. Finally, the department is small enough to provide a welcoming, personal atmosphere, in which students learn together. Student groups such as the Society of Physics Students, the Astronomy Club, and the Ladies of Robeson, provide emotional support and networking opportunities.

As in previous years, the senior exit interviews indicate that our majors continue to be very satisfied with our program. The upper level courses, in particular, receive much praise for being challenging *and* well-taught. Undergraduate research opportunities and the sense of community offered by the department are noted as particularly positive experiences. Our graduating class included several top students, such as Linh Pham who will attend graduate school at Harvard, Brian Skinner who won an NSF Graduate Fellowship (one of 46 nationwide in physics), and David Adams whose undergraduate research will result in *five* papers, four of which are co-authored with physics faculty. New courses, in areas of much current interest such as biophysics, nanoscience, and computational physics, are becoming available; other courses – especially in solid state physics and particle physics – are being streamlined.

The delivery of introductory physics courses, along with the associated laboratories, remains a key component of our teaching and learning mission. Roughly 2700 students per year, mostly from engineering disciplines, take the calculus-based sequence (PHYS 2305-06), and an additional nearly 1200 students, mostly from the life sciences, are enrolled in the algebra-based course (PHYS 2205-06). This is clearly a major enterprise. Its success depends critically on dedicated instructors and a committed GTA pool. After years of instability, the department is now fortunate to have attracted two full-time instructors, Drs. T.S. “Roger” Chang and Dan Mazilu, and one part-time instructor, Dr. Yang-Soo Kim, who carry the lion’s share of the burden, to the obvious satisfaction of their students. Several regular physics faculty are also engaged with these courses, and the lab supervision is handled entirely by regular faculty. Unfortunately, the number of GTA positions allocated to the department allows only for relatively cursory attention to the needs of our students. For example, a typical GTA can spend at most 6 minutes on the grading of a (relatively detailed) lab report which hardly allows for quality feedback.

Our Astronomy program continues to be very popular with students from a broad range of backgrounds. The two-semester introductory sequence (which includes a lab) is popular with non-science majors who wish to fulfill their science core requirements. It is taken by over 250 students per year. Astronomy remains a significant recruiting tool; conversations with incoming freshmen reveal that many of them are attracted to Virginia Tech by the astrophysics option. At the moment, the teaching load is shared between one regular faculty member, an experienced part-time instructor, and a senior GTA.

Hopefully, the impending arrival of Dr. Arav will alleviate these pressures.

The involvement of undergraduates in front-line research has become a signature effort in the department and is enthusiastically supported by the faculty. It is particularly encouraging to see *all* of the junior faculty engage with undergraduates in this way. Projects span all ranges, from computational modeling to sample fabrication at the nanoscale. Some students spend just a summer working in a lab while others spend two to three years with the same research group. Along with postdocs and graduate students, undergraduate group members travel to off-campus research locations, such as Los Alamos or the Gran Sasso neutrino facility in Italy. This early exposure to research makes our students much more competitive for national scholarships and fellowships (such as Goldwater and NSF which require formal research proposals as part of the application process) and for admission to the top graduate schools. To give more visibility to our programs and to acquire some additional funding, the department submitted a proposal to NSF to establish an REU site at Virginia Tech. Even though the proposal was declined, it reviewed quite well and will be resubmitted this year.

As in previous years, the department celebrated its Awards Ceremony in the Spring, on April 13, 2007. Nine mostly endowed awards and/or scholarships were given to 38 undergraduates, spanning all years, and five similar awards were given to graduate students. Parents, donors, and friends of the department were invited. The keynote speaker at the ceremony was Dr. Seth Smith (BS 2001). He recently received his Ph.D. from Johns Hopkins, with a thesis on magnetic resonance imaging. He is now a research associate at the Kennedy-Krieger Institute. He described recent work on quantifying MRI signatures in brain and spinal cord images, as an important component of the FDA drug approval process.

Summary data:

- The total number of physics majors is presently 112 (17 women, 3 African Americans, 3 Hispanics), slightly down from last year (124 in all, 20 women).
- The number of physics minors stands at 18 of which 4 are female (2005-06: 19 in all, 2 women).



Award-winning students, parents, donors, and undergraduate coordinator Diane Walker-Green at the Physics Awards Ceremony.

- The number of astronomy minors is substantial: 25 in total, including 4 females. This seemingly impressive increase over last year's figures (13 in all, 2 women) has a simple explanation: The students were urged to declare their minor as early as possible, rather than wait until graduation.
- Over a quarter of our undergraduate students were involved in research with faculty in the department.
- Our graduating class was larger than in previous years: In May 2006, 18 majors graduated (4 Summa Cum Laude, 4 Magna Cum Laude, and 1 Cum Laude).
- Fourteen members of the Class of 2006 will be attending graduate school; 4 will enter the work force.
- The graduating class of 2008 is expected to consist of 19 students.
- Our current numbers for incoming new students are higher than last year. For Fall 2007, 48 prospective freshmen and four transfer students have accepted admission to the Physics Department; seven of these are women, one is African-American, and two are Hispanics. Last year we had 28 new freshmen and 8 transfers.
- We continue to recruit very actively. Diane Walker-Green, our undergraduate coordinator, hosted several Physics Open House and Hokie Focus events, and visited around 20 high schools and community colleges in the Virginia, DC, and Maryland areas. To attract minority students, she attended the National Black and Hispanic Conference in Boston. Faculty and current students attend the on-campus recruiting events in large numbers and are always on hand to meet prospective students and their parents, even if they drop in unannounced.



The Class of 2007

Graduate Program

Our graduate core curriculum in its current form remains unchanged. Its main purpose is to provide a solid foundation for more advanced study. Responding to student demands and to keep pace with recent developments in the discipline, we are increasingly offering more advanced electives. This year, Computational Physics was offered, along with Statistical Field Theory; next year will see Computational Physics again, as well as Quantum Electronics (which will basically be taught as an advanced course in nanoscience), advanced Nuclear and Particle Physics, and Nonequilibrium Statistical Physics. Thanks to recent faculty hires and the strong support from our instructors, we now have the personnel to support such courses. However, our graduate enrollment needs to grow further to ensure good attendance on an annual or bi-annual basis. Hopefully, more aggressive (and selective) recruitment, additional GTA allocations, and a growth in external funding will help us achieve this goal which is an important step on the road towards improved research rankings.



Dr. Heflin shows his nonlinear optics lab to a group of prospective students, during our Graduate Preview Weekend.

This year, the department held its first on-campus Preview Weekend for prospective graduate students, on February 17, 2007. The date was chosen to coincide with the Graduate School Preview Weekend, in order to give our visitors a full picture of graduate student life at Virginia Tech. Within the department, the student were exposed to an overview of our research programs, a discussion of degree requirements and funding opportunities, a tour of our facilities and a poster session, and finally, a sampling of local restaurant options, in a more social setting. As an additional

benefit, the event showcased the full range of departmental research activities to our own faculty and students. Since all of us usually attend more specialized conferences in our own fields, this gave many of our faculty a first-ever impression of the breadth and quality of the work that is being performed here. The event was also very useful for our current first-year graduate students who are deciding on their thesis topics and advisors.

In line with university and graduate school efforts to provide better feedback, all graduate students are now interviewed once a year by the chair of the Graduate Committee. Their annual reports have been revised and will be administered more consistently, in order to monitor progress towards the degree. The prelim requirements have been tightened slightly, by insisting on a more accelerated schedule; in addition, all students are asked to find research advisors during their first year. Faculty teaching graduate courses are urged to provide realistic feedback on performance and grades, and in-class exams are strongly encouraged. Almost all faculty members are supportive of these measures and adopted them readily.

As a way of highlighting our graduate program within the Virginia Tech context, the Graduate Committee placed more emphasis on soliciting well-crafted nominations for graduate student awards. An internal nomination form was developed, listing departmental, college and university scholarships, and distributed to all faculty members well ahead of any deadlines. Several successful nominations ensued, as detailed below.

Summary data:

- The total graduate enrollment in physics stands at 54 (11 women, 1 minority). This is an increase of 18% over last year (46, 9, 1).
- There are 44 students in the Ph.D. program (last year, 37).
- Three students received their Ph.D. One has accepted a teaching position, one has accepted an internship with Credit Suisse in London, and one is planning to get married, followed by a job in the nanotechnology/IT area.
- Six students obtained the M.S. degree.
- Our incoming class currently stands at 14 acceptances with support, and one acceptance without support (a Thai student on government funding). Of these 15 students, four come from the U.S., and 11 are international. Three students are

female. We expect additional acceptances, especially from U.S. students, over the summer.

- 13 prospective graduate students visited the campus; 12 of these attended the Graduate Preview Weekend; one came to the Sowers Workshop.

The tragic shootings on April 16, 2007

Life at Virginia Tech changed irrevocably, over the span of a few minutes on April 16, 2007, when a seemingly safe environment turned into a nightmare. As everywhere on campus, the tragic shooting incident left Physics students, faculty, and staff in shock. On the one hand, we may be profoundly grateful that all members of the department were found to be safe, at least physically. On the other hand, many students and faculty lost close friends. In the days and weeks after the shootings, they had to confront their grief and any other feelings that were brought to the surface while trying to support immediate family members of the victims. The whole department came together on Thursday morning, in a ceremony of remembrance, supported by staff from the Cook Counseling Center. Several subsequent meetings were devoted to an in-depth exploration of how to return to the class room and how to support our students. With the help of the counselors, faculty, instructors and GTAs explored ways of talking about the tragic events, acknowledging grief, sadness, and anger, while making space for many different ways of mourning. The “Ladies of Robeson”, a group of female students and faculty, met Thursday evening for dinner and emotional support. When classes resumed, the vast majority of our students attended; however, once the tentative (and guaranteed) grades became known, class attendance dropped rapidly. Still, returning to a regular class schedule, reconnecting with friends, and finding Virginia Tech “still there” was doubtlessly an important step on the road towards recovery.

A particularly poignant issue concerned the incoming freshmen class whose decision date was May 1. Both the chair and the undergraduate coordinator had been in touch by phone and e-mail before the events, in order to recruit top students. After the tragedy, it became paramount to let prospective students and their parents know that the events had not changed the quality of research and education in the department and had, if anything, brought the university and the department community closer together. As of now, our freshmen admissions are significantly above those of the previous year, and the academic preparation of the class appears to be quite promising.

During this difficult period, the support of hundreds, if not thousands, of personal friends, colleagues, and alumni from across the world served as a major source of comfort.



Discovery

Physics research at Virginia Tech explores both the “internal” and the “external frontier”, to use a characterization due to a distinguished nuclear physicist, Victor Weisskopf. At the “external frontier”, the goal is to discover new elementary particles and to explore their properties and interactions; scales of energy, distance and time are pushed towards the unknown. In the department, the members of the Institute of Particle, Nuclear, and Astrophysics (IPNAS) are engaged in this form of discovery. Efforts in neutrino and nuclear physics probe the validity of the “Standard Model” of elementary particle physics while the astronomy group looks deep into the universe for exotic phenomena such as gamma ray bursts or explosions of primordial black holes. At the “internal frontier”, the constituent particles and their fundamental interactions are well known, but much remains to be discovered about how they self-assemble into a wealth of different structures, ranging from simple molecules to complex materials and living organisms. In the department, research thrusts in nanoscience and at the interface of nanoscience and the life sciences, as well as studies of complex systems and self-assembly near and far from thermal equilibrium, extend our knowledge base at this frontier. Naturally, this type of research, performed predominantly by the condensed matter group in the department, lends itself easily interdisciplinary collaborations, with faculty in the life sciences and engineering. In contrast, research in particle/astrophysics typically remains within the discipline but takes faculty far away from campus. Only large international collaborations can mount the required gigantic experimental efforts. As a result, our faculty, research associates, and students working in this area travel frequently to off-campus locations, e.g., Jefferson Lab in Newport News (VA), Pisgah Astronomical Research Institute (NC), Brookhaven and Los Alamos National Labs, Gran Sasso (Italy), Tsukuba (Japan), and Daya Bay (China). These successful programs project an image of the department far beyond Blacksburg.

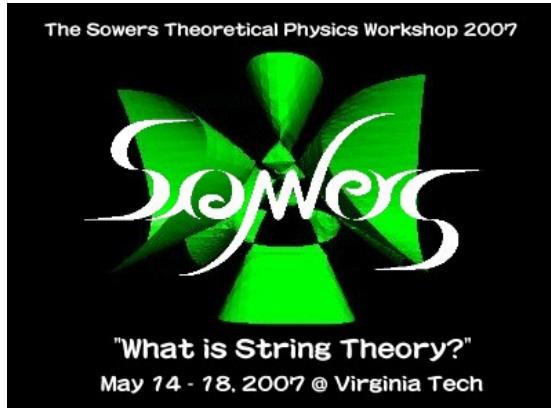


The Daya Bay Nuclear Power Plant in China, the site of a high priority neutrino-oscillation experiment, funded jointly by the DOE and its Chinese counterpart. New faculty member Jon Link is a key member of the international team of scientists who will design and run the experiment.

Summary data:

- Research Highlights:
 - Dr. Khodaparast received a Young Investigator Research Grant, from the Air Force Office of Scientific Research. She is one of only 21 scientists and engineers nationwide who are funded through this highly competitive program. Her review article “Ultrafast magneto-optics in ferromagnetic III-V semiconductors” was recognized as a *2006 Top Paper* by the Journal of Physics: Condensed Matter. This is her second major grant since coming to Virginia Tech in 2004.
 - Dr. Indebetouw’s work on scanning holographic microscopy is attracting increasing attention. With funding from NIH, NSF and ICTAS, he is developing a novel imaging technique which will allow fully three-dimensional non-invasive imaging of biological specimens with nanometer accuracy. His *Applied Optics* article “Scanning holographic microscopy with resolution exceeding the Rayleigh limit...” was highlighted in *Nature Photonics*.
 - Dr. Raghavan was one of the key contributors to the five-year long range plan of the Nuclear Physics Division of the American Physical Society. He successfully promoted the scientific urgency of the LENS project which is now explicitly included in the plan.
 - Drs. Robinson and Heflin, together with R. Davies from Chemical Engineering, received a provisional patent, for their work on the *“Enhancement of Nonlinear Susceptibilities in Organic Film Materials”*. Embedding metallic nanoparticles, with controlled sizes and spatial arrangements, into ionically self-assembled polymer films, the three researchers achieved significantly increased nonlinear optical responses. These discoveries have great potential for device applications.
 - The development of the Kimballton mine, as a suitable location for a variety of neutrino experiments and homeland security projects, is progressing. The Virginia Tech neutrino group and several other institutions (NRL, UNC, NCSU) have submitted several proposals; two of these have just been funded.
- Publications:
 - Since publications are by calendar year, it is nontrivial to provide a precise count of those published in a fiscal year. Thus, 94 journal-articles/book-chapters/invited-proceedings were published in 2006. An estimated 40 more were published in the first few weeks of 2007.
 - The Chinese translation of Dr. Takeuchi’s book *No Equations! Relativity Illustrated* appeared in Taiwan, in March 2007.
 - In collaboration with M. Henkel and R. Sanctuary, Dr. Pleimling edited two books: *Statistical Physics of Ageing Phenomena and the Glass Transition* (Journal of Physics: Conference Series 40, Institute of Physics 2006); and *Ageing and the Glass Transition*, Lecture Notes in Physics 716 (Springer, 2007).
- *Invited talks at national/international conferences/workshops/schools:*
 - Dr. Heflin: *SPIE Photonics East*, Boston

- Dr. Minic: CUNY conference on “*Non-perturbative Yang-Mills Theory*”; *Amsterdam Workshop on String Theory*; *Perimeter Institute Conference on Cosmology*
 - Dr. Park: *International Workshop on Nanomagnetism*, Coma-Ruga, Spain; *CECAM Workshop: Models and Theory for Molecular Magnetism*, Lyon, France
 - Dr. Piilonen: *DPF/JPS Meeting 2006*, Honolulu, Hawaii
 - Dr. Pitt: *Symposium on Hadronic and Electroweak Physics*, MIT
 - Dr. Raghavan: *International Conference on Neutrino Physics and Astrophysics*, Santa Fe; *6th International Workshop on Neutrino Oscillations*, Conca Speciulla, Italy
 - Dr. Takeuchi: *19th Workshop on Cosmic Neutrinos*, Kashiwa, Japan
 - Dr. Täuber: *Workshop on Nonequilibrium Phenomena in Classical and Quantum Systems*, München, Germany
 - Dr. Schmittmann, *Workshop on New Directions for Growth in Complex Systems*, Istanbul, Turkey; Fall meeting of New England Sections of APS/AAPT: *The Physics of Sports*, Worcester, MA; 2007 APS March Meeting, Denver, CO
 - Dr. Zia, Meeting of the IOP Mathematical and Theoretical Physics Group, “*Perspectives in Mathematical and Theoretical Physics*”, London, England; Workshop on “*Spontaneous Symmetry Breaking in Particle Systems far from Equilibrium*”, Oosterend, The Netherlands.
- In addition, faculty from the department presented numerous invited colloquia and seminars at universities and national labs in the U.S., Europe, and Asia.
- Visiting Scientists:
 - Dr. Hank Yochum from Sweet Briar College spent his sabbatical in Dr. Heflin’s lab.
- Conferences and workshops at Virginia Tech:
 - The Physics Department and the College of Science hosted the Zallen Symposium, in honor of the retirement of Dr. Richard Zallen, on Friday, August 18, 2006.
 - Supported by the department, the college, and the research division, the neutrino group held a workshop (“LONU-LENS”) on the physics of low energy and solar neutrinos, on October 14-15, 2006.
 - Thanks to the generous support of Mr. Mark Sowers, the First Sowers Workshop on Theoretical Physics took place from May 14 – 18, 2007. Devoted to new developments in string theory, the event attracted about 50 speakers and participants to campus.
- At present, there are 13 postdoctoral research personnel working with faculty in the department. They have a significant effect on our research productivity and form an essential component of every start-up package.



Logo of the Sowers workshop, designed by Dr. Takeuchi

II. Engagement

Members of the physics department are engaged in a multitude of activities, reaching far beyond the boundaries of the department. Within the university, physics is a key player in the nanoscience arena, through linkages within the College of Science, but also with ICTAS and the College of Engineering. Physics is also becoming a frequently consulted partner for faculty searches across the university, in the areas of quantitative biology and self-assembly in soft materials.

It is equally essential to reach out beyond the campus community, through a variety of events, activities and newsletters. Relations with alumni, donors and friends of the department, major corporations, regional schools, and the media need attention and nurturing. Within their professional communities, faculty referee extensively for journals and funding agencies. Several of them have organized conferences and hold leadership positions in their professional organizations.

At a more educational level, our student-run outreach program, which brings physics to K-12 in local schools, continues to thrive. Participating undergraduates usually return to their studies with more enthusiasm and motivation. As part of our recruitment efforts, high school students and undergraduates from other institutions participate increasingly in summer research opportunities within the department.

Alumni relations are an important component of a well-rounded department. Two events were held this year, one on-campus and one off-campus. In conjunction with the College of Science Homecoming Weekend, the “Ladies of Robeson”, a group of female students and faculty, invited several recent alumni to campus. Some of the visitors are attending graduate school, at Princeton, Duke, and elsewhere, and others are in the workforce, teaching high school physics or developing software for an astronomy publishing house. A networking event with our current students was well attended, followed by a reception, a football



Alumni Andrew Landahl (left) and Leah Shaw (right) chat with senior James Dowd, in Denver, CO.

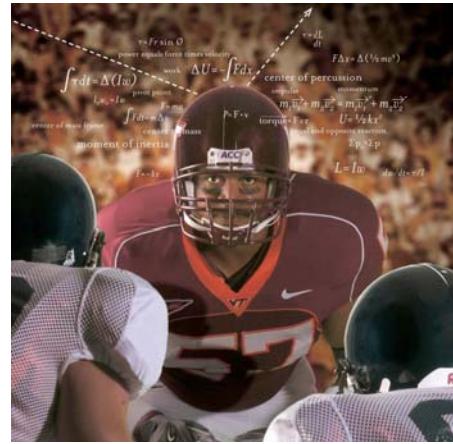
game and dinner at the Inn with all the other College of Science alumni. The off-campus event took place in Denver, Colorado, as part of the March Meeting of the American Physical Society. This large conference brings over 5000 scientists together, working in a broad range of areas, from biological physics to materials science, from quantum computing to climate modeling. Alumni, ex-postdocs and ex-faculty members joined the Virginia Tech contingent for good food and good company.

Private donations can provide much-needed additional support for a department. Years of cultivation may be necessary before a relationship has grown to the stage where a donor feels ready to make a major commitment. This year, we received numerous contributions to our graduate and undergraduate scholarships. Graduate fellowships and research support are the two areas in greatest need of development. Fortunately, significant progress was made this year, on both fronts. Thanks to the efforts of the College of Science Roundtable, a new scholarship, the Dr. James A. Jacobs Memorial Graduate Fellowship, is now fully endowed. This Fellowship honors the memory of Jim Jacobs, a long-serving faculty member and department head (1960-1973). Another new graduate fellowship is being established by an alumnus who is including the department in his estate planning. On the research side, we have received a pledge over 0.5M, to be fulfilled over the next five years, to establish a Senior Faculty Fellowship. Funds from this donation will be used to support and reward research of the highest caliber in the department. Moreover, a significant donation in support of fundamental theoretical physics, especially string theory, provided the funding for the First Sowers Theoretical Physics Workshop 2007: "What is String Theory?"

Some other highlights of our activities are listed below:

- Many of the undergraduate physics majors took part in an outreach program, conducted by the department, visiting local and regional K-12 classes/student groups and giving informative and entertaining physics presentations and demonstrations. This program was coordinated by James Robertson, a graduating senior in Physics.
- Two important annual events are the Awards Ceremony and Commencement. These events are wonderful celebrations and give us an opportunity to highlight the department to family members and friends of our students. Our donors are always invited to the Awards Ceremony; often, alumni or potential students are in town and are also always welcome.
- Dr. Heflin spoke about "Nanotechnology: Principles and Potential" at the Blacksburg Kiwanis Club.
- Dr. Khodaparast presented a lecture to the College of Science Dean's Roundtable. The Roundtable members also toured the Martin Observatory, guided by Dr. Simonetti.
- Dr. Simonetti presented a talk on Dark Energy and Dark Matter at the Graduate Life Center.
- College of Roundtable member and Physics alumnus Dr. Klaus Wiemer toured the nanoscience labs of the department. A senior executive with decades of experience in the semiconductor industry, he brings a sharp eye for business opportunities and a great passion for creative physics-driven innovations.

- Dr. Simonetti worked with Virginia Tech University Relations on a TV commercial, designed to promote the university. The commercial runs during televised sporting events. Dr. Simonetti also prepared the physics content for four ads, produced by the University Athletic Department, as part of the “Winning – It’s All in the Mind” campaign.
- Dr. Heflin served on the organizing committees for two conferences: *Lasers and Electro-Optics*, and *Organic Nonlinear Optical Materials and Devices*.
- Dr. Link was a co-organizer of the *Hadronic Shower Simulation Workshop*, held at Fermilab.
- Various faculty members are members of the editorial boards of *International Journal of Modern Physics*, *International Journal of Nanoscience*, *Journal of Modern Optics*, *Journal of Optics A*, *Journal of Physics A*, *Journal of Smart Materials*, *Journal of Statistical Physics*, *Modern Physics Letters*, *Optik*, and *Physical Review E*. They and many others also serve as reviewers for journals and funding agencies.
- Dr. Schmittmann was elected Vice-Chair of the Topical Group for Statistical and Nonlinear Physics of the American Physical Society. As part of this office, she will serve as Chair-Elect and then as Chair of the group over a period of three years.
- Drs. Heflin, Heremans, Schmittmann, and Soghomonian served as site visitors and/or review panelists for NSF. Dr. Pleimling was a panelist for the Marie Curie Fellowships of the European Commission.
- Dr. Pitt is an elected member of the Executive Committees of two leading experiments at Jefferson National Laboratories.
- Dr. Vogelaar is a member of the national NSF/DOE Neutrino Science Assessment Group. He also served on the organizing committee for the Nuclear Science Advisory Committee long-range planning process.
- Dr. Heremans serves on the ICTAS Faculty Advisory Board, and on the MICRON Group Executive Committee.
- Dr. Soghomonian coordinated ICTAS efforts to acquire an AFM/Confocal Microscope, a major equipment purchase under the Commonwealth Research Initiative. She also co-organized the 2006 and 2007 Structural Biology Symposium at Virginia Tech.
- Dr. Blecher serves on the Personnel Committee, College of Science.
- Dr. Heflin serves on the Executive (“Core”, “Cluster”) Search Committee, College of Science.
- Dr. Kulkarni was the Physics Representative for the Georgetown-Virginia Tech Initiative, exploring possible collaborations between the two institutions.
- Dr. Piilonen chairs the College of Science Curriculum Committee.



The football ad in the “Winning...” series

- Drs. Kulkarni and Schmittmann played a major role in selecting nominees for national scholarships for the Honors Program: the Campus Marshall/Rhodes Scholar Selection Committee and the Goldwater Scholar Selection Committee. Dr. Schmittmann also served on the search committee for a new Associate Director of University Honors.
- Dr. Simonetti served on a search committee in Electrical and Computer Engineering, for a new faculty member in the antennas group.
- Dr. Täuber serves on the Investigative Board and the Judicial Panel for the Graduate Honors System.
- Dr. Vogelaar is the Physics representative on VT Faculty Senate.
- Dr. Zia is a member of the Advisory Boards of *AdvanceVT* and EIGER (*Exploring Interfaces through Graduate Education and Research*, an NSF-IGERT grant administered through the department of Geological Sciences).
- Faculty members serve on one or more departmental committees. Departmental committees include standing committees: the Executive Committee, Faculty Evaluations Committee, Graduate Committee, Graduate Recruitment Committee, Undergraduate Committee, Undergraduate Committee, Shop and Safety Committee, Colloquium Committee, and the Seminar Committee. In addition, there are ad-hoc committees: Outreach (K-12) Committee, Undergraduate Research Committee, Cluster Hire Search/Screening Committee, Computational Facilities Committee and the Department Review Committee.
- Faculty members also serve in other capacities, individually: Astronomy Club Advisor (Dr. Simonetti), Demonstrations Supervisor (Dr. Pitt), Diversity Contact (Dr. Park), Martin Observatory Coordinator (Dr. Simonetti), Lab coordinator for ChemPhys Building (Dr. Pitt), Prices Fork Observatory Coordinator (Dr. Simonetti), Society of Physics Students Advisor (Dr. Soghomonian), Sigma Pi Sigma Advisor (Dr. Pitt), Webmasters (Dr. Takeuchi, with assistance from Ms. Betty Wilkins and Dr. Zia).
- Dr. Raghavan serves as the Director of the Institute for Particle, Nuclear, and Astronomical Sciences). Dr. Takeuchi is the Associate Director.

III. Diversity Activities

Bucking national trends, women are better represented at the more advanced levels in the department. Four out of 24 faculty members, i.e., 17%, are female, which is much higher than the national average of less than 10% for physics departments in Ph.D. granting institutions. 20% of our graduate student population are female, which is essentially indistinguishable from the national average of 19%. At the undergraduate level, women make up 15% of our student body. That number is quite disconcerting, since it is *much lower* than national figures (for example, nationally, women earn 22% of bachelor's degrees in physics). In fact, over the last few years, we have lost more than half of our female undergraduates during their freshmen year. However, the remaining women tend to stay for the full four year program and feel quite comfortable in the department,

according to the exit interviews. Looking for possible sources of this phenomenon, the incoming freshmen class reveals a serious gender gap: the incoming females have, on average, significantly lower SAT scores than the males. It is therefore not entirely surprising that they might feel discouraged very early on. A possible explanation may be that academically stronger women are recruited much more aggressively by higher ranked institutions.

The “Ladies of Robeson” continue to flourish. This informal group was first established by two female physics majors four years ago. Led by graduating senior Devon Triplett, this group of undergraduate and graduate students and faculty meets roughly once a month for a relaxed dinner in town or a pizza party in the department. The end of each academic year is celebrated with a potluck picnic at Dr.

Schmittmann’s house to which male students and faculty are invited. Over the past two years, the group has also organized more structured events, such as an alumni reunion during the College of Science Homecoming Weekend, and a networking dinner with NSF Program Director Maia Kukla (who happens to be the mother of one of our students, Anna Belak). As our exit interviews show, the female students value the “Ladies of Robeson” as a source of support and information, regarding course work, research opportunities, and preparation for graduate school.

Some other highlights of our activities are listed below:

- Drs. Schmittmann and Soghomonian continue their work on behalf of the Virginia Tech *AdvanceVT* program. Dr. Schmittmann serves as Co-PI while Dr. Soghomonian leads the *AdvanceVT* Scholars program, designed to attract talented women faculty to campus. Soghomonian is also a participant in the Leadership Development Program. This mentoring effort prepares mid-career women for future academic leadership roles.
- Dr. Khodaparast spoke at an *AdvanceVT* workshop on the importance of networking.
- Dr. Kyungwha Park serves on the College of Science Diversity Committee.
- Drs. Simonetti and Takeuchi play lead roles in the *Phoebe's Field* project. Led by Mitzi Vernon from the Industrial Design department in CAUS, an interdisciplinary team of designers, engineers and physicists is developing a traveling exhibition, illustrating the concept of physical fields for elementary and middle school children, especially girls.
- Minority recruiting remains a major challenge. As in previous years, Ms. Diane Walker-Green, the Undergraduate Programs Coordinator, attended the National Black and Hispanic Conference in Boston. Two female faculty members, Drs. Park and Soghomonian, have research collaborators at HBCUs. We hope to build closer relations with these institutions in the coming years. While the department



The Ladies of Robeson and many of their male peers at Dr. Schmittmann's house in early May.

counts several minorities amongst its students, the numbers in the department and nationwide are too small to warrant any comparisons of percentages.

IV. Honors and Awards

At all levels, members of the physics department have been honored in a multitude of ways. Following are the highlights.

Faculty

- Prof. Royce Zia was named a Fellow of the American Physical Society in November 2006. According to the APS, Zia was honored for “seminal and sustained contributions to statistical physics, especially critical phenomena, interfacial properties and far-from-equilibrium phenomena.” APS guidelines state that each year no more than one-half of one percent of the current membership of the society is recognized by their peers in this fashion. The organization currently has approximately 46,000 members.
- Dr. T.S. Chang was nominated by Virginia Tech students for the University Sporn Award for Excellence in Teaching Introductory Subjects.
- Two professors were honored as Virginia Tech Scholar of the Week:
 - Dr. Täuber, July 24-30, 2006
 - Dr. Heflin, December 11-17, 2006



Royce Zia

Graduate Students

- Austin Amaya received the 2007 COS Outstanding Masters Student Award.
- Juliette Mammei was honored twice for her Ph.D. research: first, by a College of Science Roundtable Scholarship Award for Graduate Study, and second, by a College of Science Outstanding Graduate Student Award.
- Sandor Benczik received a Sigma Xi Ph.D. Research Award for his work on the minimal length uncertainty relation.
- Two graduate students were interviewed by the Graduate School as *Featured Graduate Student of the Month*: Sandor Benczik in November 2006, and Saif Rayyan in May 2007.
- Four graduate students were inducted into Sigma Pi Sigma, a national honor society for Physics Students, at a banquet attended by faculty, staff, parents, and family members. Dr. Minic gave an entertaining speech about “Fundamental Physics in a Dark Age”.
- Five departmental awards/scholarships were presented to six graduate students.



Juliette Mammei

Undergraduate Students

- Brian Skinner (BS Physics and Mechanical Engineering 2007) received an NSF Graduate Research Fellowship, one of out of 46 awarded nation-wide in Physics. These prestigious fellowships are awarded on the basis of a national competition, including a detailed research proposal. Brian was also a national finalist for the Rhodes Scholarship, and Virginia Tech's 33rd Goldwater Scholar. In addition, he received a Virginia Tech Phi Kappa Phi Scholarship Award.
- David A. Adams (BS Physics and Computer Science 2007) received a Sigma Xi Undergraduate Research Award for his work on non-equilibrium statistical physics, conducted with Drs. Schmittmann and Zia. He will attend graduate school at the University of Michigan.
- James Dowd received the Accenture Corporation Scholarship from the College of Science.
- Nine departmental awards/scholarships were presented to 38 undergraduate students.
- Eight undergraduates were inducted into Sigma Pi Sigma, a national honor society for Physics Students.
- 41 Physics majors made the Fall 2006 Dean's List.



David Adams (left) and Sandor Benzckik (right) toasting each other at the Sigma Xi Ceremony.

V. Future directions

As science becomes increasingly interdisciplinary, physics needs to define itself within a much broader framework than before. Today, the solutions to critical research problems are rarely discovered within the confines of a single discipline. An open mind for the problems arising in other sciences and an ability to “speak their languages” will increasingly determine the success of individuals and disciplines. For the foreseeable future, a careful balance must be struck between discipline-specific research (which always offers the opportunity of major breakthroughs and unexpected spinoffs) and

intentionally interdisciplinary collaborations. No matter what the focus, a physicist will bring a unique viewpoint, namely, a willingness to be challenged by the unconventional and the unexpected, and a drive to seek the most fundamental, comprehensive and quantitative explanation.

The department is undergoing a significant generational change, accompanied by a major reweighting of research priorities. Well over half of the department is now working in nanoscience and/or complex systems research. To position this group even more strategically for the future, an increased emphasis should be placed on materials synthesis and control at the nanoscale. The department and the university have acquired fairly good characterization capabilities, but device fabrication capabilities are lagging behind. As a result, we remain dependent on sample growers elsewhere, limiting our flexibility and scientific leadership. A university-wide effort, driven by the College of Science, the College of Engineering, and ICTAS, to acquire a state-of-the-art molecular beam epitaxy (MBE) system would have a tremendous impact, for a broad range of disciplines on campus including physics.

With nanoscale control comes the ability to probe not only “conventional” materials such as semiconductors, but also biological molecules and more complex biological structures and networks. Again, the department has some good seeds in place, such as projects on biosensors, electronic properties of biomolecules (DNA), regulatory networks in bacterial cell-cell communication, the computational modeling of protein synthesis, and diffusion and protein complex formation on cell membranes. In all of these projects, physics plays a crucial role, by providing theoretical frameworks, such as statistical approaches far from thermal equilibrium, or sophisticated characterization tools, such as custom-built nanoscale devices for sensor applications or transport measurements, or novel holographic imaging techniques. A few strategic hires, with strength in biological and/or medical physics, combined with a few well-chosen hires in the materials area, will keep the department at the cutting edge of modern science for at least one if not two decades.

Beyond materials and biologically inspired research, the department has another strong focal point: the particle physics group is coalescing around neutrino physics. Following a variety of different experimental and theoretical approaches, the different group members are exploring the properties of one of nature’s most elusive and intriguing particles, the neutrino. A better understanding of this particle has been given one of the highest priorities of physics funding, at both NSF and DOE. In comparison to high energy particle physics at large accelerators, R&D costs in neutrino physics are roughly two orders of magnitude lower and therefore more easily justifiable to the tax payer. The collaborations are also considerably smaller (50-100 scientists rather than thousands), so that a department like ours, which is still much smaller than a top-30 department, can play a leadership role. While a major push, to establish the nation’s “Deep Underground Science and Engineering Laboratory” at Virginia Tech, was not successful, it did propel our neutrino group into the international limelight, and they now play signature roles on national planning and advisory committees. Future goals include fusing this group into a coherent team of experimental and theoretical researchers, building the signature experiment, LENS (Low Energy Neutrino Spectroscopy) in the Kimballton mine, and

exploring the connections to astrophysics, possibly through the study of cosmic relic neutrinos.

With the new hire in astrophysics, we are optimistic that this field will become a small but highly distinguished research focus of the department. Astrophysics captures the mind of the public in ways that few other science fields do, and offers enormously rich research problems. As large-scale particle accelerators become prohibitively expensive, physics is looking ever deeper into space, to explore exotic matter and to probe the very fabric of space and time. Particle physics and astrophysics merge here. Observational astronomers, antenna and wireless engineers, neutrino physicists, detector experts and string theorists can find common ground here and create a completely new synergy.

Pursuing large scale funding opportunities will be a high priority for the department. To be competitive for a Materials Research in Science and Engineering Center (MRSEC) or a Physics Frontier Center (PFC), a unique research portfolio is necessary to provide a firm foundation. Yet, a number of other building blocks should also be in place: outstanding faculty with strong funding records (implying that single PI grants will remain crucially important, since they provide this “seal of approval”); a record in student training (through successful REU and IGERT grants), strong university support, in terms of research space and large-scale shared experimental facilities (the MBE system would be critical here, at least for materials research), and good K-12 outreach programs and diversity efforts. Other factors, such as corporate connections, partnerships with other universities or national labs, and international outreach, will also come into play. It will be essential to keep these fundamentals in mind.

Our educational programs have to remain strong and focused on excellence if we want to compete successfully in REU and IGERT competitions. Students flourish and develop better in a supportive climate, offering early exposure to research as well as mentoring and career advice. Courses will be continually monitored, streamlined, and infused with the latest scientific discoveries, both at the undergraduate and the graduate level. We will resubmit our REU proposal from last year and continue to explore different avenues which may result in additional graduate teaching and research assistantships for the department. One essential avenue is to increase development activities. Fortunately, a number of faculty members are aware of the importance of this activity and are beginning to participate. The targeted areas are scholarships for graduate students, departmental postdoctoral fellowships, endowed chairs for junior faculty, support for a distinguished lecture series and/or symposia and workshops, as well as funding for research activities in general.

Finally, Physics is scheduled to undergo a departmental review in 2007-2008. Intense discussions and data collection efforts are underway. Since the last review occurred over ten years ago, this activity is long overdue. Indeed, the face of the department has changed beyond recognition since then. So has the environment in which it finds itself, from the local academic to the wider global setting. With the help of the review, the department will position itself strategically to take full advantage of swiftly evolving boundary conditions.

Part 3: Additional Information

Grants received:

Externally funded grants since July 1, 2006:

(From OSP database, Project Authorization Notices, and Faculty Activities Reports)

Investigator(s)	FRS	Amount	Agency
Blecher	477503	\$80,000	NSF
Heflin	415419	\$33,000	SBIR
Heflin	415484	\$50,000	Luna
Khodaparast	443973	\$10,000	Jeffress
Khodaparast	477365	\$93,000	NSF
Khodaparast	477365	\$14,000	NSF-REU
Khodaparast	430251	\$109,943	AF-OSR
Kulkarni	443971	\$10,000	Jeffress
Park	443010	\$10,000	Jeffress
Piilonen	429151	\$180,000	DoE
Pitt, Morgan	477345	\$93,000	NSF
Robinson	443028	\$35,000	Jeffress
Takeuchi, Minic	420190	\$147,500	DoE
Vogelaar	430031	\$20,000	NRL
Vogelaar, Raghavan	477355	\$360,000	NSF

Grants awarded by funding agency; FRS not yet determined:

Investigator	FRS	Amount	Agency
Heflin	TBA	75,000	Prime Photonics
Schmittmann, Zia	TBA	\$195,000	NSF
Vogelaar, Pitt	TBA	\$115,206	NSF
Piilonen, Link	429151	\$50,000	DOE
Link	TBA	\$20,000	Jeffress

To summarize, the total amount of funding per year, administered by PIs from the Physics Department, comes to approximately \$1.70M.

In addition, faculty from physics serve as Co-PIs on several major grants. The total share for the department is approximately \$405K for this FY. Two examples are:

- Dr. Heflin is Co-PI on a major 5-year MURI grant from the Army Research Office, with PI Tim E. Long from Chemistry. Heflin will receive a share of \$130,000 per year which he will use to fund several graduate students in his lab.
- Dr Simonetti is a Co-PI on a 3-year NSF grant, together with Drs. Ellingson and Patterson from ECE. The grant funds the construction and initial operation of a radio telescope array (the ‘Eight-meter-wavelength Transient Array’) which will monitor virtually the entire sky for transients from a variety of high-energy astrophysical phenomena including primordial black holes, gamma ray bursts, supernovae, and compact object mergers.

Other interdisciplinary involvements generate funding for equipment or students, but no overhead. The approximate amount of this type is \$240K. For example:

- Drs. Heflin, Kulkarni, and Schmittmann are part of the EIGER project. Administered in Geosciences, this IGERT grant supports three graduate students in physics, including their stipend, tuition, travel and support costs.
- Drs. Khodaparast and Indebetouw received small seed grants from ICTAS; Dr. Kulkarni has a similar grant from IPBHS.

In total, this translates into research funding for the department of approximately \$2.35M.

New Faculty Hires

- Dr. Jonathan Link, Assistant Professor (August 2006)
- Dr. Michel Pleimling, Associate Professor (August 2006)
- Dr. Eric Sharpe, Assistant Professor (hired in 2006-07, start date August 2007)
- 2 postdoctoral research associates
- Offers made in this FY:
 - Dr. Nahum Arav, Associate Professor; accepted
 - Dr. Patrick Huber, Assistant Professer; still under negotiations

Faculty Promotions and Retirements

- Dr. Mark Pitt was promoted to the rank of Full Professor;
- Dr. Bruce Vogelaar was promoted to the rank of Full Professor;
- No retirements took place this year.

Staff Hires, Promotions, and Retirements

- There were several significant changes at the staff level. Ms. Judy Faw, our senior fiscal technician, resigned abruptly in July 2006. The position was subsequently

- advertised, and Nora Bentley joined the department in October of 2006. She has settled in very well, and all fiscal aspects of the department are running smoothly.
- In July of 2006, Mr. Scott Allen was promoted to supervisor of our machine shop, following the retirement of his predecessor, Melvin Shaver.
 - As a consequence, Mr. Allen's position became vacant. A search resulted in the hire of Ron Stables in September 2006. With these turnovers, the machine shop is now fully staffed again.
 - The position of a technician to assist in undergraduate laboratories and development of lecture demonstrations was filled in August 2006. Our new staff member is Josh Peebles who graduated from our undergraduate program in May 2006. Together with several student workers, he is maintaining all of our teaching labs.
 - Business Manager Kim Dix went on short-term disability on January 8, 2007. She has not returned to work since then. This has led to major pressures on the department. The university will need to find ways to address such long-term absences in key positions.

Undergraduate Research

- Partial list of undergraduate students involved in research in Physics:

<ul style="list-style-type: none"> ○ David Adams ○ Michael Avery ○ Daniel Baker ○ Anna Belak ○ Elizabeth Bonnell ○ Aaron Burger ○ Daniel Davis ○ James Dowd ○ Kevin Finelli ○ James Forester ○ Jessica Gorzo ○ Brandon Harp ○ Jonathan Hughes ○ Chris Knorowski 	<ul style="list-style-type: none"> ○ Elizabeth Lowry ○ Julian McMorrow ○ Reza Montazami ○ Jo Ellen Narron ○ Brandon Nipper ○ Annalisa Pawlosky ○ My Linh Pham ○ Brian Skinner ○ Brett Spencer ○ Samantha Stone ○ Stuart Strommen ○ Devon Triplett ○ Emily Wade ○ Eric Ward
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- Some details (further links on <http://www.phys.vt.edu/undergradresearch.html>):
 - James Dowd, My Linh Pham, and Eric Ward worked in Dr. Hereman's lab, on nanoscale fabrication and characterization of magneto-transport in InSb structures and thin films.
 - Anna Belak and Daniel Davis worked on the synthesis and AFM imaging of DNA assemblies on various surfaces, supervised by Dr. Soghomonian.
 - Jo Ellen Narron and Chris Knorowski are developing detector components for the Daya Bay experiment with Dr. Link.

- Jessica Gorzo is running density-functional theory calculations for small molecules, in the research group of Dr. Park. Jessica is also writing code and analyzing data for the ETA telescope array, with Dr. Simonetti.
- Kevin Finelli is working with Mark Pitt on hardware and software projects for the Qweak collaboration.
- Devon Triplett and Elizabeth Bonnell are working with Drs. Vogelaar and Pitt, helping to prepare and coat neutron guides for the UCN-A experiment.
- David Adams has computed and analyzed the power spectrum of the totally asymmetric simple exclusion process, with Drs. Zia and Schmittmann. This work has been accepted by Physical Review Letters. He is also preparing a publication on applying such simple models to protein synthesis in environments with limited resources.
- Julian McMorrow is working with Hans Robinson on the fabrication of metallic nanostructures for surface plasmon enhancement of non-linear optical effects in polymer films.
- In the group of Drs. Schmittmann and Zia, Brian Skinner was modeling host-parasite population dynamics in the context of non-equilibrium statistical mechanics. He also worked with Bruce Vogelaar on pulsed laser deposition for the Ultra Cold Neutron experiment in Los Alamos.