

## PHYSICS

A UNIVERSITY  
EXEMPLARY  
DEPARTMENT

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Dr. Lay Nam Chang  
*Professor, Dept. Chair*

Dr. John Ficenec  
*Professor, Assoc. Chair*

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Ms. Deborah Cruise  
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# Quanta

A publication for the faculty, staff, students, alumni  
& friends of the Virginia Tech Physics Department

## "Dear Alumni" *A personal statement: Chairman, Lay Nam Chang*



As we enter upon another year, there is a lot among the department's accomplishments that I can take pride and pleasure in. All of these are collective efforts on the part of the faculty and staff. I can say without equivocation that we have excellence in both.

The department has made enormous strides in repositioning ourselves after the large number of retirements of a few years back. We have been fortunate to attract some top-notch researchers to join our ranks, and they have already begun to make an impact both here in Blacksburg, and in the national and international scene. Our research emphasis has undergone subtle but significant shifts, and we now have expertise in areas that we have not had in the past. Among these are discernible presence in materials research, molecular electronics, nanoscale science, non-equilibrium systems in general, and in biophysics. In particle physics, we are now involved in high visibility experiments at the Jefferson Lab at Newport News, and in neutrino physics experiments at Gran Sasso in Italy. We are also beginning to have a stake in string theory. Along the more traditional areas, our efforts in the BELLE collaboration at the KEK Laboratories in Japan have paid off. We played a key role in this past summer's announcement of the discovery of a significant amount of matter-anti-matter asymmetry in the

*Continued on page 4*

## "Eyes on the skies" **The colors of the universe**

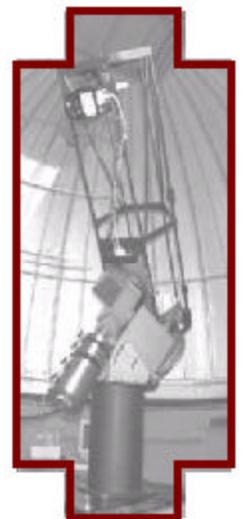
*computers and their passion for astronomy.*

Mountain Lake — People hike Salt Pond Mountain for the views of ridge lines blurring into West Virginia. But it's the sights at night that attract Lisa Francis, James Roberts and Mike Lyons to Giles County — the sights few people ever see.

The three Virginia Tech students usually drive out from Blacksburg long after dark, when the peaks are hidden but the heavens are open to be explored. At the Flossy Martin Observatory, using sophisticated computer gear and an arrangement of mirrors that Isaac Newton designed, they may spend hours collecting even a single image too faint for the naked eye to detect.

"You can't see anything like this on Earth," Lyons enthused.

Francis, Roberts and Lyons are among a group of students who are assembling color pictures of distant stars and galaxies: slick professional-



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## “Eyes on the skies”

*Continued from page 1*

looking images like the ones in science textbooks. The laborious undertaking is a project for their Observational Astrophysics class, a course that involves everything from tracking asteroids to learning when the moon clears the trees. But the work also stems from a passion the students say has lasted for years.

Roberts, a 22-year-old from Chantilly, can't remember a time when he wasn't fascinated with the night sky. Majoring in physics at Tech — the university offers only a minor in astronomy — he plans to start a combination master's and doctoral program in astronomy next year at the University of Colorado.

Lyons, 20, recalled that as a child in Norfolk, he would wake up to see lunar eclipses. His father gave him a telescope “but we never could get that to work,” he said laughing. Francis added, “When most little kids were telling their Mom and Dad they wanted to be firefighters, I was telling my Mom and Dad I wanted to be an astronomer.”

Now 22, the Annandale native laughs as she describes how when she came to college, she majored in art. But her astronomy dreams persisted, sometimes emerging in the Neptunian land-scapes of her drawing and sometimes in projects like she is doing now with the space images. “It's just like art, it really is,” Francis said of the astronomy class.

The scientific side of the students' work is readily apparent at the observatory. Dedicated in 1991, it is part of the Miles C. Horton, Sr. Research Center, a complex donated to Tech by tobacco fortune heir Miles Horton Jr. The observatory is one of several facilities Horton named after Flossy Martin, a high school teacher whom he credited with inspiring his life-long interest in science.

A simple-looking telescope, really just two mirrors and a framework, sits atop a concrete pillar that extends 10 feet or so into the ground. The heavy base is isolated from the rest of the building — the floor is cut out around it — to prevent vibrations from shaking the instrument.

The students are using a 0.4-meter telescope. The size refers to the diameter of its light-gathering parabolic mirror. The largest optical telescopes are the twin 10-meter Keck Telescopes in Hawaii. The telescope peers through a slit in the 16-foot diameter dome that tops the observatory and is rotated by computer controlled motors to offset the Earth's rotation. The computer, in a nearby control building, also must correct for the slight flexing of the telescope's metal framework as it pivots to various positions. These are tiny movements, but enough to spoil the telescope's aim across such vast distances, explained professor John Simonetti, who teaches the astronomy class.

*M81 - Combined R.V.B. images taken by Joe Chin, Jon Harris, Josh King, and Mike Lyons using the Virginia Tech 0.4m Telescope - PHYS 3154 Observational Physics.*



*The M81 galaxy is 12 million light years from Earth, encompasses 100 billion stars and is about the same size as our Milky Way galaxy. Virginia Tech students Mike Lyons, Joe Chin, Josh King and Jon Hams created the picture through a series of long-exposure images.*

The artistic element Francis mentioned comes into play as the students put color to their pictures. It's an open question what distant stars really look like. The human eye sees far-off space in shades of gray. That's because the eye captures just a small fraction of the light that hits it, not enough to assign color to the dim images that even a powerful telescope reveals.

Color photography, which used to be used in observatories, also has problems with color balance and resolution, Simonetti said. The computer chip mounted on the observatory's telescope is much more sensitive, but it operates only in narrow frequency bands, leaving any single image essentially a two-tone portrait.

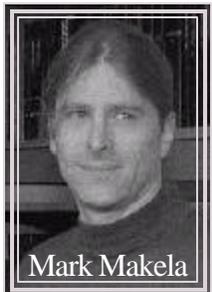
“It's hard to know how your eye would respond,” if such far-off objects could be seen up close, Simonetti said. The students build their pictures by combining three long-exposure images of the sky. For a picture of the M81 spiral galaxy (the number refers to a catalog of celestial objects assembled by 18th-century French astronomer Charles Messier) Lyons and his teammates took an eight-minute exposure around the red end of the visible spectrum, a 15-minute exposure for greens and a 20-minute exposure for blues. Including set-up times, the process took well over four hours, Lyons said.

Francis and Roberts took 4½ hours to build a picture of the Crab Nebula. A full-color picture is created when the three

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## “Grad student to meet Nobel laureates”

**M**ark Makela, a Virginia Tech Ph.D. student in physics, is one of eight doctoral students selected by Oak Ridge Associated Universities (ORAU) to attend the annual meeting of the Nobel laureates in Lindau, Germany, where he will have the opportunity to discuss his development of a new specialized coating for storage of neutrons, a fundamental subatomic particle.



Nobel laureates in chemistry, physics, physiology, and medicine have convened in Lindau on an alternating basis for one week each summer since 1951 for open meetings with promising science students and young researchers. This seminar provides top science students from around the world a unique opportunity to spend time with key figures in the scientific community as well as meet students from other parts of the world with similar or complementary scientific interests.

Makela was selected for his work in nuclear physics on the Ultra Cold Neutron 'A' Correlation (UCNA) experiment at Los Alamos National Laboratory (LANL). The UCNA experiment takes a high-precision look at neutron-beta-decay asymmetries; the values of these asymmetries are used to test the current fundamental models of physics.

Makela said, "Theoretical physicists predict that polarized neutrons decay asymmetrically -- more electrons are emitted one direction than the other. Our experiment will give the most precise measurement of this asymmetry to date, which can be used to guide theorists to a better model of our physical world."

This experiment uses neutrons, which are cooled to near absolute zero (Ultra Cold Neutrons) and then polarized in a very strong magnetic field. The particles are polarized when their spins are aligned, like compasses in the earth's magnetic field. "At these low temperatures, neutrons can be contained in bottles, bouncing around like superballs until they decay -- each becoming a proton, electron, and anti-neutrino," Makela said. "This experiment detects the electron emitted from the decaying neutron and logs its direction and energy." Makela's main contribution to this experiment is the development of diamond-like carbon-coated guides which will transport the polarized UCN through the experiment. The guides have been developed at Virginia Tech using a wide range of the campus' available resources. Makela's UCN guides are quartz tubes with an amorphous carbon film deposited on the inside using a pulsed-laser system developed at Virginia Tech. "Films made with this process are as dense

## Excerpts from students and alumni

**Leah Shaw (98)** - *Current graduate student at Cornell University.* The physics department encourages its students to participate in undergraduate research and often provides research experience for undergraduates (REU) funding from the National Science Foundation. The most obvious benefit of under-graduate research is that it allows students to determine whether they want to pursue a career in scientific research and in what area they should specialize. My experiences strengthened my desire to conduct theoretical physics research. Graduate School admissions committees and scholarship selection committees prefer applicants who have a clear idea of their long-term goals. Because of my undergraduate research experiences, I was able to make specific and convincing statements about my plans when I completed applications. Also, my ability to succeed in science had been tested and proven. As a result, I was accepted to several top graduate schools and awarded the prestigious National Science Fellowship for Predoctoral Research. Undergraduate research experiences also provided specific tools that will be helpful in my future work. ⚙️

**Mark Wallace (99)** - *Current graduate student at Michigan State University.* The work I have done through the physics department here has helped me in many ways. First, it has kept me interested in the subject of physics and provided me a constant reminder of why we spend so much time studying and attending classes. It has helped me decide what sub field of physics that I should specialize in for graduate studies. I will be attending Michigan State University in the fall to work toward my Ph.D. in physics. When the faculty there read about and talked to me about the research experiences at Virginia Tech, they were very impressed, and offered me a research position starting the summer before I actually start my class work there. The research experiences I have had here at the Virginia Tech physics department have proven so valuable to me and I believe its value will continue to grow as I continue my education and on into my career in physics. ⚙️

**Jean Hager (99)** - *Current graduate student at MIT.* While I attended Virginia Tech I participated in three different undergraduate research projects through the Physics Department. The first involved a collaboration with the EE Dept., the second entirely in Physics, and the third a collaboration with Chemistry. In all, the undergraduate research projects I have worked on have been both interesting and enlightening. I have been able to work in a number of different settings and have participated in different styles of research. I believe this experience will help me to make informed choices in graduate school and beyond when I must decide what research group I will work for. I have learned about many different areas of research and how to use equipment important to those areas. Finally, in participating in collaborations with other departments, I have been able to see how physics is applied in a wide range of situations. ⚙️

*Continued on page 7*

## Two physics students are among four to receive the Barry M. Goldwater Scholarship

Jay Mettetal and Beth Reid were awarded the prestigious Barry M. Goldwater Scholarship this past year. Mettetal and Reid are both junior physics and math double majors. Each will receive a maximum of \$7,500. The award covers expenses for up to two years, and can be used for tuition, fees, books, and room and board. The scholarship targets students who are specifically interested in basic research. ⚙️

## Department gift to the American Red Cross

In an effort to aid victims and families affected by the terrorists attack of September 11, 2001, members of the Physics Department contributed \$1,350 to the American Red Cross.



“And on behalf of the American people, I thank the world for its outpouring of support.”

- President George W. Bush

## Physics professor wins Humboldt Research Award

Royce Zia uses a checkerboard and a computer game to illustrate his physics research. Zia, professor of physics at Virginia Tech, won an Alexander von Humboldt Research Award for his work in the area of theoretical condensed matter physics, a discipline devoted to the understanding of the cooperative behavior in systems with large numbers of constituent particles.

The Alexander von Humboldt Foundation, located in Germany, grants up to 150 Research Awards annually to foreign scholars with internationally recognized academic qualifications. The award is a lifelong tribute to the past academic accomplishments of award winners, who are invited to carry out research projects of their own choice in Germany in cooperation with German specialist colleagues for six months to one year.

Zia's main research topic is the study of the statistical mechanics of driven diffusive systems, a special class of physical systems far from thermal equilibrium. Typical systems consist of too many constituents to be described in detail, such as air molecules in a room. Nevertheless, thanks to statistical mechanics, many overall properties can be predicted. The goal is to understand how a variety of macroscopic states emerges from an ensemble of simple microscopic constituents. “As we know,” Zia said, “though ice, water, and steam have very different properties, all are results of  $H_2O$  molecules subjected to very simple interactions. Another good instance is a collection of carbon atoms, which can form ash, graphite, diamond,

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## “Eyes on the skies”

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images are combined, and the students adjust the color balance until it seems right.

“You try to do it as scientifically as possible and then you just try to make it look good,” Roberts said. They're quick to point out that their pictures are as realistic as they can make them, and Simonetti agrees the pictures are less fanciful than some colorized photos released by scientists at the National Aeronautics and Space Administration. In the end, though, the students said they draw satisfaction as much from the process as from the finished results. “For me, astronomy's always been looking for things I've seen in books and seeing what they look like for myself,” Lyons said. “Anybody can take a camera and go out and take pictures of things on Earth.” ⚙️

Courtesy acknowledgement, “The Roanoke Times”

## “Dear Alumni”

Continued from page 1

B-meson sector. This goes a long way toward improving our understanding of how the present universe came about after the Big Bang.

I am particularly happy to report that funding for the new building that will house our teaching labs has been released. Bids have gone out, and we look forward to occupancy in a couple of years from now. We have some projects that we are working on that we think will drastically change the way introductory labs will be taught. These changes will be beneficial for all of our students. Some of them have been described in the last issue of *Quanta*, and more will be forthcoming in future issues.

There is still much that we need to do. President Steger has defined a challenge for all of us when he put the University on track to be among the

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## Nanoscience earns awards for faculty members

*Courtesy acknowledgement, "Susan Truelove, Virginia Tech Spectrum"*

Promising research to develop transistors from molecules and wireless transmitters as small as a few hundred atoms has earned Virginia Tech faculty members Massimiliano Di Ventra in physics and Stephane Evoy in electrical and computer engineering each a Ralph E. Powe Junior Faculty Enhancement Award from Oak Ridge Associated Universities (ORAU).

The Powe award recipients received \$5,000 each in unrestricted research funds from ORAU, which is matched by Virginia Tech. The Powe awards provide seed money for research by junior faculty members at ORAU member institutions. Each institution may only submit two applications.

"Virginia Tech is a double winner," said Ron Townsend, ORAU president. "Based on your research, we never doubted you were going to be winners. I'm proud to present this award to people of your calibre."

Reporting that Oak Ridge National Laboratory is proposing a nanotechnology lab, Townsend said that Di Ventra and Evoy will be important collaborators.

Evoy said nanotechnology is a broad and interdisciplinary area of research that has been growing explosively world wide in the past few years. A nanometer (nm) is one-billionth of a meter or about the size of 10 atoms. "Working with materials on that scale has the potential for revolutionizing the ways in which materials and products are created, and the range and nature of functionalities that can be accessed," he said. "The dimension reduction has provided previously unavailable functionalities in many areas, such as access and engineering of quantum phenomena in opto-electronics and higher speeds and reduced power consumption in micro-electronic systems."

Evoy specifically investigates nanoscale mechanical structures. "Dimension reduction in mechanical systems bestows higher resonant frequencies, potentially greater durability, and ultra-sensitive detection of forces," he said. "Specifically, a nanomechanical beam with lateral dimensions of tens of nanometer (a few hundreds of atoms) would resonate in the gigahertz range (oscillate one billion times per second). Such

devices would allow the development of RF subsystems that could bestow a substantial size reduction of wireless devices down to wristwatch dimensions."

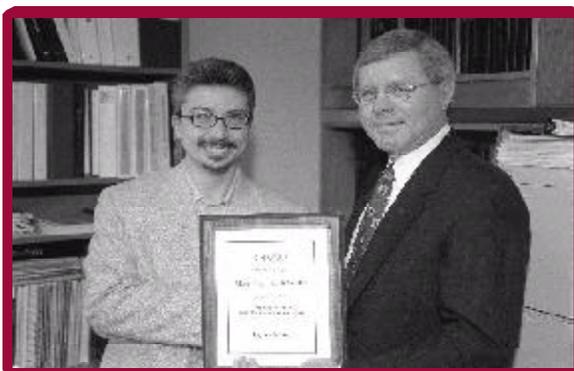
While at Cornell University, Evoy was involved in the nanomachining of structures with dimensions as small as 30 nm, and mechanical-resonance frequencies in the hundreds of megahertz. "However, issues ranging from materials science to industrial amenability hinder the further deployment of nanoelectro-mechanical systems (NEMS)," he said. "For

instance, energy dissipation is highly problematic at such dimensions. Furthermore, nanomechanical systems demand a drastic revision of design approaches." Evoy and the Virginia Tech NEMSLAB are addressing such issues, and are confident about the eventual deployment of nanomechanical structures in consumer applications. Di Ventra's research is enlarging the fundamental understanding of the transport properties of molecular devices in particular, how current flow can change the structure of molecular devices and how current fluctuations

(shot noise) can affect the development of this scale of electronics.

Computing has reached a technological and physical limit in the number of transistors that can be integrated into a single chip. A new generation of nano-scale electronic devices that can perform functions identical or analogous to those of the transistor and other key components of microcircuits, and which can out perform the integration level of today's chips at a manufacturing cost comparable to the present technology, is needed. Researchers in the new field of molecular electronics aim to create immensely powerful computing circuits based on trillions of individual building blocks, each no larger than a single molecule. However, a more fundamental understanding of the transport properties of molecular structures at the atomic level is required.

Di Ventra is providing theoretical background for the development of molecular devices by means of accurate first-principles calculations of their transport properties: specifically, current-induced forces (electromigration) and statistical effects (quantum-shot noise). Di Ventra discovered



*Massimiliano Di Ventra (left) with Ron Townsend (ORAU president) (right)*

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## “Virginia Tech physics professor wins Humboldt Research Award”

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and, more recently, Buckyballs and nanotubes.” The impact of cooperative behavior can be appreciated from examples far from physics. In a party, talking to non-physicists, Zia likes to use the analogy of a collection of children. “Even if the interaction between two children leads to well-behaved play, we can imagine the result of having 30 of them in a living room instead. On the other hand, a dramatically different state will ensue if we put the same set of kids in a football field.” The examples of  $H_2O$  molecules and carbon atoms noted above represent cooperative behavior in thermal equilibrium. By contrast, under conditions far from equilibrium, the same collection of particles can produce an even greater variety of states. The key difference lies in the presence of some form of energy flowing through non-equilibrium states. Examples range from physical patterns like snowflakes to the full biological gamut.

Zia’s research focuses on the question common in all these cases: How do complex macroscopic patterns emerge from a few simple dynamical rules governing the evolution of microscopic constituents? In search of an answer, he looks for the bare essentials needed to produce complex behavior, through the study of simple model systems that display rich and surprising phenomena.

Zia uses a checkerboard to illustrate one such model. Given a few of the red and black checkers arranged on the board and trying to move against each other, Zia imposes a few simple rules: A piece moves randomly forwards or sideways by single steps (provided the target square is empty), and, when pushed off the board, they can “wrap around” to come back up on the other side. If only a few checkers are present, they can manipulate their way around their opponents, he demonstrates, but when more and more pieces are added, a new pattern emerges.

They lose options for movement, forming clusters that grow to resemble clouds and, finally, crashing into a giant stalemate. The essential ingredients for the transition to occur, in this case, are inherent randomness and the two preferred directions of movement. An analogous phenomenon occurs in familiar daily life: traffic jams. With fast cars and slow trucks in a multilane highway, clustering (or jams) occurs when too many vehicles are present.

To illustrate the importance of randomness, Zia shows the fragility of intricate patterns in the game of ‘Life’ on the computer, which relies on deterministic rules of evolution. The addition or removal of a single “individual” can destroy a self-replicating “colony.” “On the other hand, stochastic rules pick out robust patterns instead of fragile ones,” he said. “Most of the steady states around us are stable against small, random perturbations. To build simple models for these stable patterns, it is crucial to incorporate stochastic rules.” Although the main goal of Zia’s work – the search for overarching principles that underlie non-equilibrium statistical mechanics – is general and abstract, the models studied have potential applications in many areas. Apart from traffic jams, other examples may be found in biology (e.g., electrophoresis – a method commonly used in DNA analysis, rates of translation in protein synthesis, biological motors) or materials science (e.g., superionic conductors, polymer dynamics, surface growth, granular flow.)

The tools of his trade range from sophisticated mathematical techniques (stochastic differential equations, path integrals, renormalization group) to down-to-earth computer simulations of pieces

jumping around on a checkerboard. While advanced mathematics is needed in the final understanding of how complex patterns emerge, it is simulations that facilitate the discovery of these surprising phenomena. The latter are especially suited for undergraduates to participate fully in this research program. In recent years, a dozen students have been involved in his projects.

In addition to publishing in a wide range of professional journals, Zia is co-author of a book entitled *Statistical Mechanics of Driven Diffusive Systems*, published by Academic Press in 1995.

He has been invited to give presentations and lectures at numerous conferences, workshops, and summer schools. Zia has earned a number of other awards, including a Humboldt research fellowship, a research scholarship awarded by the Committee for Scholarly Communications with the People’s Republic of China and U.S. National Academy of Sciences, and a Fulbright Travel Award. He has received Virginia Tech’s certificate of teaching excellence twice.

Last year, Zia was invited to spend five months at the University of Essen in Germany as a scientist in residence and was able to devote all his time to research. In addition to scholars in Germany, he collaborates with researchers in Canada, England, Holland, Hungary, Denmark, Switzerland, and Taiwan.

Zia also collaborates closely with Beate Schmittmann and Uwe Täuber, both professors of the Virginia Tech physics department. This year, their projects involve four postdoctoral associates, six Ph.D. students (five on campus and one in the Northern Virginia Center), one M.S. student, as well as two undergraduates.

Their research is funded by grants from the Division of Material Research of the National Science Foundation, NATO,



Professor Royce Zia

*Continued on page 8*

## Nanoscience research earns awards for faculty members

*Continued from page 5*

that the contact region between molecules and electrodes in particular, its geometry and chemistry plays a crucial role in the transport properties of molecular devices. These findings have redirected attention from the initial emphasis on the electronic properties of isolated molecules to the formation and characterization of their contacts with bulk electrodes. Now, Di Ventra seeks a more fundamental understanding of this relationship that can eventually lead to the "design" of molecule-lead contacts with reduced electromigration effects, he said. He will also address prediction of the voltages at which specific molecular devices fail to operate, the role of electrical contacts in generating high resistance and their role in generating quantum-shot noise, and the operating mechanisms of molecular field-effect transistors. His research will span both fundamental aspects related to the transport properties in nanoscale structures, and engineering issues related to the feasibility and functionality of actual molecular devices.

His work in molecular electronics has been featured twice in *Nature* and in other national journals. He has filed a patent on power-electronics applications. ⚙️

"Virginia  
Tech is a  
double winner"  
~Ron Townsend

## Grad student to meet Nobel laureates

*Continued from page 3*

as diamond and extremely smooth, with roughness of less than a nanometer," he said. His films appear to be the best nonmetallic neutron reflectors in the world. Makela will be presenting work done on these films at several European laboratories this year, where they are being considered for use in other UCN experiments. Makela's research is part of the UCN project at LANL, which is sponsored by the Department of Energy. The Virginia Tech part of this project is funded by the National Science Foundation.

"I would like to thank my adviser, Dr. (Bruce) Vogelaar for nominating me for this award and taking me as a graduate student," Makela said. "I would also like to thank Dr. (Robert) Hendricks and Dr. (Carlos) Suchicital of MiCroN and the materials science and engineering department for letting me use their laser system and for their help in making this project possible and Dr. (Gary) Pickrell for his technical input." Last year was the first year the United States participated in the Nobel Laureate Travel Grant Awards. ORAU managed the program for U.S. Department of Energy (DOE), who funded participation by 30 students. With the sponsorship of LabBook Inc., Alberto de la Fuente will also meet with the Nobel Laureates in Germany. De la Fuente, a Ph.D. student in the Free University of Amsterdam, is doing research at the Virginia Bioinformatics Institute at Virginia Tech under the supervision of Pedro Mendes, research assistant professor. De la Fuente's research is on the subject of "Metabolic Control of Hierarchical Systems and Dynamics of Genetic and Metabolic Networks."

Mendes said, "Our research is about the interactions between genes, proteins, and small biochemical compounds in the cells (metabolites). Traditionally, genes have been studied in isolation from proteins and metabolites, but new developments in genomics, such as DNA chips, are making it possible to study genes in context." ⚙️

*Courtesy acknowledgement, "Susan Truelove, Virginia Tech Spectrum"*

## New faculty members

**Djordje Minic** - joined the theoretical particle physics group on August 10, 2001. Dr. Minic obtained his diploma in Electrical Engineering from Belgrade Univ., Belgrade, Yugoslavia in 1988. The same year he was awarded the Nikola Tesla prize for his undergraduate research. Minic earned his Ph.D. in physics from the Univ. of Texas at Austin in 1993, as part of Steven Weinberg's theory group. He held postdoctoral research positions at the City College of the City Univ. of New York, Penn State Univ., and the Caltech-USC Center for Theoretical Physics. He was also appointed a Visiting Scholar at the Enrico Fermi Institute at the Univ. of Chicago. His research focuses on string theory and its applications in field theory, particle physics, gravitational physics and cosmology. His work on string theory has appeared in more than thirty publications in various national and international journals. He has given numerous presentations at national and international conferences, workshops and seminars. Dr. Minic has collaborated extensively with many scientists from the United States, Europe and Asia. ⚙️

**Norman Morgan** - filled the position of Sr. Research Assoc. in our Electronics department on May 10, 2001. He received his B.A. (cum laude) in Physics with a minor in Philosophy at West Virginia Wesleyan College in 1978. In 1984 he received his Ph.D. in Experimental Particle Physics at Duke University. Norman is not a new-comer to the physics department, considering he held a prior appointment as Research Scientist from 1989 until 1999. Norman specializes in the repair and calibration of precision measuring tools such as (mechanical and electrical) micrometers, calipers, indicators, height gages, etc. ⚙️

### “Virginia Tech physics professor wins Humboldt Research Award”

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and the Jeffress Foundation. Two of the postdoctoral associates are supported by the German Research Council (DFG) and the Swiss National Science Foundation. ⚙️

*Courtesy acknowledgement, “Sally Harris, Virginia Tech Spectrum”*

### “Dear Alumni”

*Continued from page 4*

top-30 research institutions by the end of this decade. What can Physics do to be a major player? While we have been discussing some ideas, we welcome input from you to meet this challenge. And we need your help and support. The department and I are very appreciative of the generous donations from many of you. We look forward to similar commitments from everyone.

I thank all of you for your continued interest in Physics at Virginia Tech. Please do feel free to drop by when you have the chance. Or, please e-mail us or call us at any time. We love to hear from all of you. So that we may continue to be in touch, please do take the time to provide the information requested at the end of this newsletter. ⚙️

*Best regards, Lay Nam Chang*

## Where are you, and what are you doing?

We love to hear from our alumni! Please keep in touch by visiting our alumni website at [http://www.phys.vt.edu/alumni/alumni\\_form.html](http://www.phys.vt.edu/alumni/alumni_form.html), or fill out the form below and mail to: Virginia Tech, Department of Physics, Robeson Hall 0435, Blacksburg, Virginia 24061-0435.

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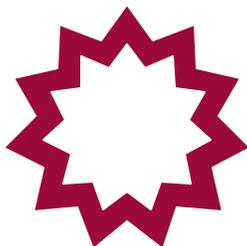
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