Quantum Leap
University of South Carolina
Department of Physics and Astronomy
Spring 2006

Another Honor Bestowed on the USC Department of Physics and Astronomy

On December 9, 2004, Dr. Frank T. Avignone, Carolina Endowed Professor of Physics and Astronomy, was awarded the honorary doctoral degree *Honoris Causa* by the University of Buenos Aires. Upon his arrival in Argentina, he and USC professor Horacio A. Farach were received by Ambassador Lino Gutierez, the U.S. ambassador to Argentina, for an hour of informal discussions concerning cultural and scientific exchange between the United States and Argentina.

In the early 1990s Professors Avignone and Farach visited Argentina to organize a series of USC-led collaborative astrophysical experiments involving the United States, Argentina, Spain, Greece, and Israel. These represented some of the first experiments of their kind, in the terrestrial searches for the hypothesized Cold Dark Matter. This theoretically predicted, but yet unobserved, "missing mass" is needed to explain the observed structure and dynamics of galaxies. Astrophysicists long ago concluded that without the gravitational pull of the Dark Matter within them, spiral galaxies could not maintain their tight spiral structure over the millennia, but would have cast their stars far off into space. Dark Matter could also explain how the early universe condensed from an elementary particle "soup" shortly after the "Big Bang" into the galactic structure observed today.

These experiments were performed far down in the southern hemisphere to take advantage of the fact that a detector located there would have the earth in a position between the Dark Matter and detector part of the day, modulating any detected signal in a predictable way. The same detector was later used in a most sensitive search for elementary particles, called axions, hypothetically created in the sun. The theory of the unique detection mechanism used was developed for this application by USC physics professor Richard J. Creswick. These experiments were the bases for the Ph.D. dissertations of two of Avignone's graduate students, Dr. Juan Collar, now on the faculty of the University of Chicago, and Dr. Federico Hasenbalg, of the University of Bern in Switzerland.

Frank T. Avignone came to USC in January 1965. He served as chair of the USC Department of Physics and Astronomy from 1979 until 1998, when he stepped down and accepted his present position as Carolina Endowed Professor of Physics and Astronomy. Among his other honors are two Russell Research Awards in Science, in 1973 and again in 1991; the Jesse Beams Medal of the American Physical Society for "Significant Research in Physics" in 1994; the South Carolina Governor's Award for "Excellence in Science" in 1995; a Senior Fulbright Scholar Award to Italy in 2002; and the Outstanding Leadership Award of the Oak Ridge Associated Universities in 2003. He is a fellow of the American Physical Society and has been funded continuously for the past 25 years by the National Science Foundation. His present grant supports his leadership roles in two international experiments to determine the mass of the neutrino using the exotic nuclear double-beta decay. This problem has recently been given the highest priority by the American Physical Society Select Committee on Neutrino Research, commissioned jointly by the National Science Foundation and the U.S. Department of Energy. In spite of his long career at USC, he continues to look to the future here.

The USC physics department has had a long list of prizes awarded to its faculty. International recognition was given to Professor Yakir Aharonov, a member of the National Academy of Science, in the form of the

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UNIVERSITY OF SOUTH CAROLINA

From the Chair

A Message from the Chair

The Department of Physics and Astronomy has seen many changes during the last academic year. A major organizational change at the University of South Carolina took place with the merger of the College of Science and Mathematics and the College of Liberal Arts. The new College of Arts and Sciences officially came into being in January of 2005 and is the largest college on the Columbia campus. It comprises 24 buildings and more than 500 faculty and 8,200 students. The new dean of the college, Dr. Mary Anne Fitzpatrick, comes to us from the University of Wisconsin-Madison.

Concurrent with all these changes, the Department of Physics and Astronomy has continued to grow on all fronts. Our extramural funding as well as the number of refereed papers and invited talks is up, our enrollment both at the undergraduate and graduate levels has increased, and we have had three new tenure track faculty hires. I would like to welcome our new faculty, Dr. Thomas M. Crawford, Dr. Roberto Petti, and Dr. Steffen Strauch.

Dr. Crawford comes to us from Seagate Research Center (Pittsburgh, Pa.) and has become an integral part of the condensed matter group and the USC NanoCenter. His vast expertise in high-frequency measurements and his projects to construct sophisticated scanning probe for magnetic measurements at the nanoscale are innovative and will broaden the scope of the current condensed matter research. His proposed research will have both fundamental and applied parts. Fundamental aspects will cover quantum magnetism whereas applied research will be linked to novel electronics devices and data storage development.

Dr. Petti comes from the CERN laboratory in Geneva, Switzerland. His research interests focus on the properties of the neutrino and complements the USC neutrino effort currently carried at the Fermi National Accelerator Laboratory outside Chicago. With this increase in manpower, the high-energy research group has become one of the strongest in the Southeast. It will be able to increase its extramural funding and bring large construction projects to the USC Columbia campus.

Dr. Strauch comes to us from George Washington University. His list of research accomplishments are already impressive and show that he has the ability and vision to grow into a world-class nuclear physicist. Dr. Strauch is the lead investigator for two approved experiments at the Thomas Jefferson National Laboratory that complement the efforts of the USC experimental nuclear group. His addition to the department will strengthen the existing efforts and provide the opportunity to compete for large-scale grants.

Chaden Djalali

Beyond the strategic plan, the department has engaged in a thorough discussion on how to benefit from the University plan to hire more than 150 new faculty members in the next three to five years. While our primary goal is to maintain and develop our current strength, we are looking into the possibilities of creating new areas of research through multidisciplinary programs.

During the current academic year, the Department of Physics and Astronomy is conducting, in accordance with its approved strategic plan, four searches. Three searches for tenure-track faculty members in the areas of experimental nanotechnology/condensed matter, foundation of quantum physics, and theoretical condensed matter. The fourth search is for an endowed chair position in medical physics associated with the South Carolina Brain Imaging Center of Excellence (BICOE). In 2004 the SC General Assembly agreed to fund the state's research universities through the South Carolina Research Centers of Economic Excellence Act to create research professorships and centers. The BICOE was the first of these funded centers and will become a world-class brain imaging center and industrial cluster spanning MUSC and USC.

All the tenure and promotion cases put forward by the department had a successful outcome. Dr. Ralf W. Gothe was granted tenure and was promoted to full professor with tenure, Dr. Milind N. Kunchur has been promoted to full professor, and Dr. Varsha P. Kulkarni has been promoted to associate professor with tenure. The department wholeheartedly congratulates them.

It is also with great pleasure that we have learned that Dr. Richard A. Webb is the first recipient of the John Palms Bicentennial Professorship in physics.

During last year the department successfully hosted the LONCAPA workshop in January and the international workshop "Theoretical Problems in Fundamental Neutron Physics" in October.

Last but not least, I would like to thank all the alumni and friends of the department who through their generous donations and contributions to the different physics funds, have truly helped us make a difference.

Nuclear Theory Group

Professor Fred Myhrer and Professor Kuniharu Kubodera

Our two graduate students, Ivan Danchev and Barbara Szczerbinska, are close to finishing their Ph.D. dissertations. Ivan is investigating the pion production process from two protons, which has been a serious challenge in nuclear theory for many years. Barbara is calculating the neutrino-nucleus scattering rates that play a vital role in contemporary astrophysics.

The current members of the Nuclear Theory are: Branton Moncriffe, Barbara Szczerbinska, Ivan Danchev, Kuniharu Kubodera, and Fred Myhrer.

This last year Kubodera and Myhrer gave invited lectures at international conferences in Europe and Asia on the subjects of neutrino-nucleus reactions and the electromagnetic corrections to the neutron lifetime. These are topics of great current importance since they affect the interpretation of the most advanced measurements of fundamental particle properties (the quark mixing properties or the CKM matrix) and the question of "new" physics beyond the Standard Model.

Our postdoctoral fellow, Dr. Youngman Kim, obtained a position at the Korean Institute for Advanced Study (Seoul, Korea) and left USC in September 2005. Our new postdoctoral fellow, Dr. Anders Gardestig, joined us in December 2005.

Our former graduate student Petronio (Wilson P. Alvarez), who received his Ph.D. at USC with Kuniharu and Myhrer in 2002, has become a lecturer at the Universidad Central de Ecuador in Quito, Ecuador. This is one of the oldest universities in South America.

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Wolf Prize, awarded in the Israeli Knesset, the Israel Prize for Exact Science, and the Cresson Medal of the Franklyn Institute. Professor Fred Myhrer received the King's Gold Medal in Science, by the King of Norway, and Professor Horacio A. Farach, a member of the Argentinian Academy of Science, received the Luis Leloir Medal from the President of Argentina. The prestigious Gravity Essay Award was won by professor Jeeva Anandan (deceased) and Professor Pawel O. Mazur.

Three USC physics professors have been recipients of U.S. Department of Energy Outstanding Junior Investigator Awards: Professors Sanjib R. Mishra, Milind V. Purohit, and Carl Rosenfeld. South Carolina Governor's Awards in Science were awarded to Professors Yakir Aharonov and Frank T. Avignone. In addition to Avignone, six other physics faculty members have received Russell Research awards—Professors Ronald D. Edge, Kuniharu Kubodera, Charles P. Poole, Horacio A. Farach, Barry M. Preedom, Colgate W. Darden, and Jeeva Anandan—while USC Educational Foundation Research Awards have gone to Professors Chi-Kwan Au, Gary Blanpied, and Chaden Djalali.

In the area of teaching awards, Professor Ronald D. Edge won the Pegram Medal of the Southeastern Section of the American Physical Society and served as president of the American Association of Physics Teachers. Professors Farach and Djalali are recipients of both the Amoco and Mungo Awards. They are also both winners of the prestigious Board of Trustees Distinguished Professorships. Professor Milind N.Kunchur also received the Mungo Teaching Award.

Avignone, who recently completed 41 years on the faculty at USC, said that he is proud of the many contributions and achievements of the department and his colleagues and looks forward to at least another decade of exciting research at USC.

Nanoscience Researcher Webb Named First Holder of Palms Bicentennial Professorship

Dr. Richard A. Webb, internationally known for his research in nanoscience, has been named the first recipient of USC's Palms Bicentennial Professorship in physics. Named for former University president Dr. John M. Palms, the award was created in his final year of service to attract high-profile scientists to the Columbia campus.

Webb became the first scientist hired under South Carolina's $30 million endowed chairs program. A former physics professor at the University of Maryland, Webb managed the quantum electronics program at IBM's T.J. Watson Laboratory and was recognized for his work with multiple awards, including three Outstanding Technical Achievement awards.

Richard A. Webb, center, receives the award from President Andrew A. Sorensen, left, and former president of USC John M. Palms.

In with the New

The department was fortunate to hire three new faculty members last year, and they arrived on campus this fall. They are excited to be here; halfway through their first year they offer us a snapshot of their current thoughts.

Thomas Crawford was an industrial researcher with Seagate. His previous work dealt with high density magnetic media (can you say "Ipod?").

Thomas Crawford

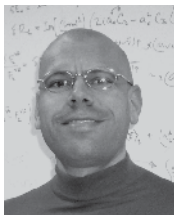
His comments: "The solutions to the toughest problems our society faces—for example, a scarcity of fossil fuels, rising health-care costs, and bioterrorism—will be found creatively via a multidisciplinary team of forward-thinkers discovering and using science. Assembling such a team requires the right location and the right research university."

"With its modest cost-of-living, family-friendly amenities, and proximity to the ocean and mountains, Columbia is poised to be one of the next growth destinations." [Editor's note: Anyone spending time hiking or biking in Harbison State Forest is likely to run across Thomas cruising the trails on his mountain bike—one of the extracurriculur activities he loves.]

"I also intend to craft a methodology to prepare our students for interdisciplinary teamwork, for creative thinking, and for broad career aims, while still grounding them in the core elements of our field."

"I have seen the excitement in the eyes of my students at the prospect of using state-of-the-art experimental condensed matter physics techniques to conduct an experiment they proposed, and they are hungry to do physics in addition to learning about it."

Roberto Petti is the third member of a strong group of high energy physicists at South Carolina studying the physics of neutrinos. He comes to us from CERN, the premier high-energy physics laboratory in Europe.



Roberto Petti

He says, "I decided to come to the University of South Carolina mainly because of the opportunity to carry on my research in the field of neutrino physics, which is one of the main points in the Fermilab research plans for the next few years. Actually, this is my first experience in United States. The first couple of months (I arrived on August 15, 2005) were very busy, and I'm still in the process of discovering the place. I can say it's quite an interesting experience for me since life here is so much different from Europe, and I'm learning many new things almost every day."

Steffen Strauch comes to us from George Washington University. He has joined our "excellent research group in experimental nuclear physics."

Steffen Strauch

His comments: "My research interests are close enough to take advantage of a fruitful collaboration within the group while at the same time different enough to overall strengthen and diversify the activities of the group."

"Columbia is a great place to live. I bought a house (my first real-estate purchase) and can ride my bike to work. Affording a house close to work would have been impossible for me at my previous workplace in Washington, D.C."

"I have taught before at George Washington University and enjoyed it very much. I'm looking forward to teach PHYS 211 in the spring. Being supported to do fundamental research is a privilege; teaching is one way to return some of that favor to society."

All of our newcomers are building strong research programs and supplementing that with a dedication to teaching.We welcome them to Carolina.

Staff News

The staff of the Department of Physics and Astronomy has remained unchanged. Bill Campbell, Ray Edmonds, Richard Hoskins, Mary Papp, Beth Powell, Bob Simmons, Robert Sproul, and Lynn Waters are all still here.

The biggest news among the staff is that Rick and Mary Papp welcomed their first child, William Charles (Will) Papp, on August 21, 2005. Will weighed in at 10 pounds, 6.2 ounces. Negotiations are underway to sign him to the USC football team. His parents (who are Clemson fans) seem to be resisting the idea.

Sadly, Beth's cat Doc disappeared this year, but she still has Molly and Sarah. Lynn still has her two cats, Emily and Henry, and Mary and Rick still have their dog, Hawker, but they found new homes for the two turtles. Robert still enjoys Blanche's goats, and she also has acquired a donkey, Samson, to help herd them. Robert and Blanche also have a new cat, Snookums, who came to them as a very young kitten that had had both his hind feet mutilated in what was probably a leghold trap. After surgery, an extended stay at the vet, and much recuperation, Snookums is well on his way to becoming a full-grown cat that is absolutely spoiled. Bill's daughter Lucy has a new pet snake named Nakey (Lucy named her) to go along with her two dogs, Dobbs and George. Nakey is a western hognose, and Lucy likes to tell people about how Nakey ate a mouse.

The department's staff includes (front row) Mary Papp, Lynn Waters, and Beth Powell and (back row) Bob Simmons, Robert Sproul, and Richard Hoskins.

High-Energy Physics

The last year has witnessed several metamorphoses in the group's personnel. Jae Jun Kim and Chris Kullenberg, who began working with the neutrino subgroup as first-and second-year undergraduates, received their bachelor's degrees and are now enrolled in our Ph.D. program. Both are planning to do their research with the high-energy group.

Jae Jun Kim, who in 2004 was named a Goldwater Scholar, in 2005 was awarded a National Science Foundation Graduate Research Fellowship. Ryan White, who first worked with our group as a summer intern in his undergraduate years, rejoined the group to pursue his doctoral research. Postdoctoral fellows Tim Bergfeld and Achim Weidemann both moved on. Bergfeld took a position with General Electric in the division that designs and fabricates superconducting magnets for medical resonance imaging. We are now recruiting a replacement. Weidemann, who was already resident at SLAC, now has a staff position with the laboratory. His replacement is Dr. Woochun Park, whom we welcomed to the heavy-quark subgroup in October 2004.

The High-Energy Physics Group is (front row) Sanjib R. Mishra, Milind V. Purohit, Xurong Chen, Karen Wu, Jiajie Ling, and Iulian C. Bandac and (back row) Chris Kullenberg, Jae Jun Kim, Carl Rosenfeld, Matthew Seaton, Jeffrey R. Wilson, Ryan White, and Woochun Park.

In May 2004 the department concluded its search for a new faculty member for the high-energy group with a first offer to Dr. Roberto Petti, who was then on the research staff at CERN in Geneva. In August 2005 Professor Petti settled into his office on the sixth floor of PSC and launched his teaching career with a formidable class of physics majors and students from the Honors College. Petti has considerable experience with neutrino physics in the context of the NOMAD experiment, and he plans to continue with neutrino physics in his new position.

The heavy-quark group has continued its work on BaBar, which has been operating reliably in factory mode for several years. The PEP-II accelerator at SLAC is now delivering peak luminosities three times above the original design. The integrated luminosity is expected to quadruple by 2008.

The group's newest member, Woochun Park, has been doing research at a remarkable pace, shouldering a service task at the same time as he pursues three analysis projects. The analyses are measurement of the CP violation parameter gamma in the decay $B^0 \to D^{*-} \rho^+$, a search for double charmonium production, and observation of $B^0 \to K^{*+} \rho^-$.

Professor Jeffrey R. Wilson and graduate student Xurong Chen have begun searching for the η_b particle, the lightest of the b-quark containing mesons. Given all the b-quark physics done since 1977, it is surprising that no one has yet observed this particle. Now, with BaBar's tremendous statistics, Wilson and Chen may be the first to see this particle.

Professor Milind V. Purohit has been working with graduate student Hongxuan Liu to create a BaBar data set for the determination of form factors controlling the decays of D mesons, which contain a charm quark. Liu has trained several artificial neural nets in the process and has implemented some clever twists to their usual architecture.

With student Ryan White, Purohit has been working on particle identification on the BaBar experiment. White has been studying the systematic errors for kaons and pions in an effort to bring them down to the sub-one-percent level. This effort will be the key to a search for direct CP violation in the future.

Purohit and Wilson are engaged in additional BaBar service tasks. Wilson is continuing as Drift Chamber Simulation manager. Purohit, having completed his term on the BaBar Publications Board, has become a co-convenor of the Particle ID group within BaBar.

The agenda of the neutrino subgroup has changed little in the last three years, but the projects have advanced considerably year after year. The venue of the front line projects is Fermilab. Early in 2005 the MINOS neutrino oscillation experiment commissioned its Near Detector. The comparison of the neutrino energy spectra obtained from the Near Detector and the Far Detector, commissioned in 2003, yields the principal result of the experiment. Commissioning of the NuMI (neutrinos at the Main Injector) beam line also started early in 2005, and by April neutrino events in the Near Detector were a fait accompli.

After commissioning, the beam line suffered two malfunctions; one was a cooling water leak in the primary target enclosure and the other a ground fault in the downstream "horn," which focuses the pions en route from the target to the decay tunnel, where they decay to neutrinos. Aside from the two-week interruptions caused by these incidents, data collection has been continuous, and the lab's physics program called for more of the same until a shutdown in March 2006. The collaboration looks forward to presenting its first results from anthropogenic neutrinos at summer conferences in 2006. Professors Sanjib R. Mishra and Carl Rosenfeld, postdoctoral fellows Tim Bergfeld and Andrew Godley, and graduate student Karen Wu have been participating in MINOS.

Our work on the MIPP experiment also continues apace. Our interest in this hadroproduction survey experiment is tightly coupled with

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Undergraduate Research

Gary Blanpied

The University administration has been working to increase the participation of undergraduates in all areas of research. Each spring Discovery Day highlights undergraduate research. Here in the Department of Physics and Astronomy we have a long-established culture of including undergraduates in our research that goes back to the late 1950s. Ron Edge tells me that there are still high-energy physics detectors buried somewhere near the Thomas Cooper library. In addition to using grant funds to support students, we have created two research courses, PHYS 499 and ASTR 499, that allows students to get 3 hours of credit for working on a research topic with a professor.

In 2004 I mentored Luay Hammami (Carolina Scholar), and later he joined the research group (High-energy physics) of Sanjib R. Mishra. Jae Jun Kim worked with Sanjib and received both a Goldwater Fellowship and a National Science Foundation (NSF) Graduate Research Fellowship, was included in *Who's Who among Students in American Colleges and Universities*, and earned our Outstanding Senior Award (Nina and Frank Avignone Fellowship). Chris Kullenberg has worked with both Sanjib Mishra and Carl Rosenfeld. Both Jae and Chris are now in our graduate program. Josh Hendrickson (Phi Beta Kappa Freshman Scholar Award) and Kevin Wilson joined the group and spent much of Christmas and the summer taking shifts at Fermi National Laboratory. Both Josh and Kevin are studying abroad now, Josh in Russia and Kevin in Japan. Abe Pernicka started working for Milind V. Purohit in the summer of 2005 on B-quark physics.

The nuclear group has used part of their NSF grant each year for 26 years to employ undergraduate students in their research. Yossef Korang-Behesti (another Outstanding Senior Award winner [Nina and Frank Avignone Fellowship]) worked for Dave Tedeschi for several years until he graduated last May and left us for graduate school at Duke University. Joshua Paul Witthuhn (Rudy Jones Physics Award) worked for both Tedeschi and Ralf Gothe until his graduation in May 2005. He headed to graduate school at Rensselaer Polytechnic Institute in fall 2005. Eugenia Lydia Senn (Carolina Scholar, College of Arts and Sciences Rising Senior Award in Physics) has worked for Ralf Gothe both for PHYS 499 and for compensation. In May 2005 Kevin Ludwick started working with Ralf Gothe, and Oliver Gothe started with Dave Tedeschi. Brandon Eubanks started working with Ralf Gothe in fall 2005.

Mary Keane (Carolina Scholar) worked for Ruslan Prozorov on nanoscience topics. Ruslan left in summer 2005 for Iowa, and our newest hire in nanoscience, Thomas M. Crawford, formed a group including undergraduate students. He included a laboratory research project for each of the eight students in PHYS 512 Solid State Physics in fall 2005 and held a poster session in late November to highlight the results.

Christina K. Lacey (Radio Astronomy) has had three students take ASTR 499 at the same time: Dan Hightower, Jon Stenbeck, and James Stapleton. Also, Noelle Luce (public relations major) worked with her until she graduated in spring 2004.

Joe Johnson (Complex Problems Group) has a large number of collaborators, including one undergraduate, John Matthew Rabon (biology major).

There is so much activity by our faculty and students that I am sure I have overlooked someone.

International Workshop, "Theoretical Problems in Fundamental Neutron Physics"

The International Workshop organized by the Department of Physics and Astronomy was held October 14–15, 2005, on the University campus. Prominent scientists from Canada, France, Germany, Russia, the United Kingdom, and the United States gave lectures and exchanged research ideas at the workshop, which was also attended by young researchers and graduate students. The total number of participants exceeded 80, and they represented almost all leading research centers in the world that are active in the field of fundamental neutron physics.

Since the advent of intense cold neutron facilities nearly 30 years ago, a wide variety of fundamental neutron physics measurements have shed much light on important issues in nuclear physics, particle physics, astrophysics, and cosmology. Currently, a new generation of such experiments is being planned, and new sources of cold neutrons are under construction. The first new neutron source—the Spallation Neutron Source (SNS) at the Oak Ridge National Laboratory—will be in operation in mid 2006.

With the prospect of new and more accurate measurements, it was appropriate and timely to review the status of the theory associated with these experimental improvements with an eye toward the clarification of unresolved issues as well as the identification of the breadth of physics that can be addressed at SNS.

The workshop focused on theoretical issues related to neutron beta decay, hadronic parity violation, the neutron electric dipole moment, and neutron-antineutron oscillations. A number of invited experimental talks gave an overview of the current status of relevant experiments and their expected progress. The local scientific organizers of the workshop were: Vladimir Gudkov, Kuniharu Kubodera, and Fred Myhrer.

The details of this workshop can be found at www.physics.sc.edu/TPFNP.

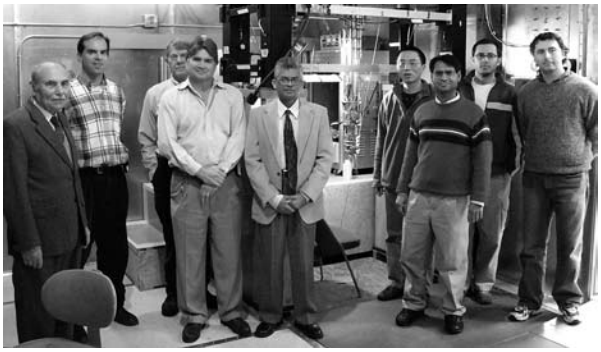
Condensed Matter Group

In August of 2005, Dr. Thomas M. Crawford joined the USC NanoCenter and the Department of Physics and Astronomy as an associate professor. Dr. Crawford was recruited from Seagate Technology in Pittsburg, Pa., where for six years he worked on high frequency dynamics in magnetic materials and new technologies for characterizing and extending the storage density and data rate of magnetic recording systems.

Dr. Crawford received his bachelor's degree in 1992 from Haverford College in Haverford, Pa., and did his graduate studies at the University of Colorado in Boulder, Co. He received his master's degree in 1995 and Ph.D. degree in physics in 1997. He then went to the National Institute of Standards and Technology (NIST) as a National Research Council Postdoctoral Associate, where he demonstrated coherent control over magnetization dynamics at <1 ns time scales for achieving optimal switching speeds in magnetic devices, studied interface magnetostriction in magnetic multilayers, and implemented new metrologies to identify fundamental limits to magnetic recording at nanometer length and picosecond time scales.

At Seagate, Dr. Crawford conducted groundbreaking research on spin wave excitations in patterned ferromagnetic elements, invented new technologies for extending the storage density and data rate of magnetic recording systems, and developed new ultrafast techniques for studying magnetic films and devices. He has more than 30 publications in both basic and applied research along with five issued patents and three published patent applications. He has received two Outstanding Contribution awards and a Key Contributor award. He is a member of the American Physical Society and active in the Division of Condensed Matter Physics, the Forum on Industrial and Applied Physics, and the Forum on Physics and Society. He is also a member of IEEE Magnetics Society and IEEE Lasers and Electro-Optics Society.

Thomas M. Crawford's subgroup of condensed matter specialists features (left to right) Robert J. Heaton, Bradley T. Knaus, and Crawford.



The Condensed Matter Group includes (left to right) Horacio A. Farach, Thomas M. Crawford, Richard A. Webb, Richard J. Creswick, Timir Datta, Yuanzhen Chen, Milind N. Kunchur, Samir Y. Garzon, and Gabriel F. Saracila.

At USC, Dr. Crawford will set up a state-of-the art laboratory for fabricating and measuring a variety of magnetic structures. His focus will be on basic understanding of how to use the spin of an electron to create new devices that work at very high frequencies. He will have the ability to deposit and etch 6 different materials without breaking vacuum, which is necessary for modern day multi-layer magnetic sample. He will set up optical lithography for device patterning down to the one micron scale complimented with electron beam lithography to produce devices with features as small as 20 nanometers. He will have a femtosecond pulsed laser for coherent control of spin dynamics and a wide variety of high frequency and optical electronics for magneto-optical measurements. In addition, Dr. Crawford will have a variety of scanning probes that will be used for sub-nanometer spatial sensitivity with sub-picosecond temporal resolution. He plans to collaborate with members of the physics, chemistry, and Electrical engineering departments to increase the scope and impact of his research.

Dr. Crawford is already trying to establish collaborations with small start-up companies and large corporate research and development organizations with the goal of ensuring that the science and technologies he develops get quickly transferred to industry. These collaborations can lead to career opportunities for undergraduate, graduate, and postgraduate students he plans to have working in his laboratory.

Milind N. Kunchur's research in condensed matter physics in the areas of superconductivity and disordered systems has been highlighted by the DOE in their report to Congress. Professor Kunchur has presented his research at international conferences in the United States, Japan, Greece, India, and Ukraine. Milind is also involved in research in musical acoustics and hearing perception and has found new limits to the resolution of human hearing. He was invited to give a tutorial talk on this subject at the 2005 March meeting of the American Physical Society (APS).

Richard J. Creswick and Horacio A. Farach continue to work with Frank T. Avignone on the physics of low temperature bolometers as part of the CUORE collaboration. The CUORE experiment is looking for zero-neutrino double beta decay by measuring the change in temperature of single crystals of tellurium oxide when a radioactive decay takes place within the crystal. The bolometer must be cooled to millikelvin temperatures so that the heat capacity is small enough that the energy deposited by a single nuclear event is sufficient to produce a detectable change in temperature. Creswick, Farach, and Avignone are exploring the possibility of using materials containing other double-beta decay nuclei, especially neodymium and molybdenum. Professor Creswick is continuing his research into the time reversal and the second law of thermodynamics.

Horacio A. Farach is collaborating with a team of doctors and molecular biologists in Argentina to develop a treatment for cystic fibrosis. Initial clinical results are very encouraging, and Professor Farach is actively pursuing support from the Cystic Fibrosis Foundation and the National Institutes of Health.

Student of the Month

November 2005: Luay Hammami

Luay Hammami standing amid a tangle of cables in a charged particle detector in the Department of Physics and Astronomy

In summer 2005 Luay Hammami was immersed in Arabic language studies at the University of Damascus in Syria. The Columbia, S.C., native and USC student has family ties to the region and a great interest in the history and culture of the land of his parents, Ifran and Ena Hammami (also of Columbia). He plans to return to Syria in spring 2006 to more fully embrace his language studies in the land of his ancestors. Given his interests in language and the extent to which he has traveled to study it, one might not suspect that Luay is a senior physics major in the College of Arts and Sciences working with a high-energy physics group headed by Dr. Sanjib Mishra of the Department of Physics and Astronomy at USC. As of spring 2005, Luay has also added history as his second major. He feels a strong intellectual attraction for physics and history, as both represent chances to search for universal relationships in different ways, one through people and events, and the other through particles and forces.

It is this desire for finding unity in diversity in his undergraduate program, and insights into the sciences and humanities, that sets him apart, both as a student and a person. Ultimately his choices reflect on the very nature of the mission of the College of Arts and Sciences itself, which is to promote and support opportunities for all its students over the widest range of inquiry possible. As a student in our college, a Carolina Scholar, and a member of the Honors College, Luay has a multitude of avenues to engage in his intellectual and personal development. He has followed one of those paths in research, in which he has been supported this year with a research fellowship from the Honors College to continue his studies in physics. Other paths lead back to places far from home.

As Luay prepares to return to the University of Damascus in the spring to extend his command of the Arabic language, he takes the experiences and skills he has developed at USC abroad with him once again. He takes a little of us to the far corners of the world and brings back new experiences from which we all can grow. While he may not yet know where his degree will ultimately lead him, his academic preparation in the College of Arts and Sciences provides him with the intellectual tools and communication skills needed to be successful in whatever he may choose to do. We are proud to have him as our student of the month.

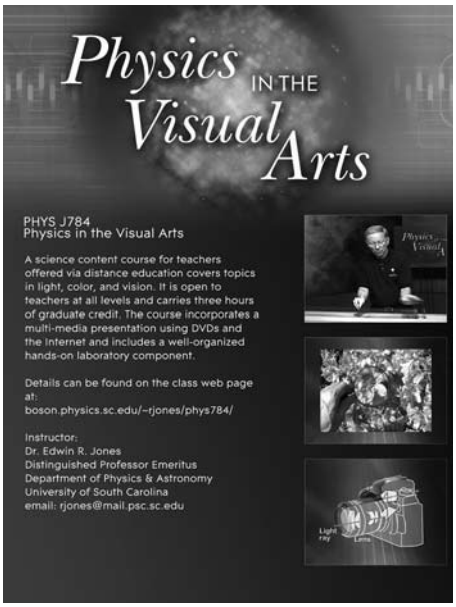
Physics Department Offering Internet / DVD Courses

By combining the Internet with DVD technologies, the department is now offering PHYS 153 Physics in the Visual Arts via Distance Education. Two versions of the course are available: an undergraduate course for art and media arts majors and a graduate course for middle and high school teachers. Most of the students in the undergraduate course come from nearby and enroll through the Columbia campus, but the graduate students come from all around the state.

Last fall, with the help of the Instructional Services Department, Professor Edwin R. Jones recorded a series of demonstration lectures on DVDs that form the core of the course. The students supplement the lectures through hands-on experience with a kit of supplies that includes lenses, prisms, diffraction gratings, a spectroscope, a laser, and more. With the kit and the accompanying lab manual, the students are able to carry out the very same experiments they would perform if they were taking the class in our teaching laboratory.

The class is built around fourteen DVD lessons that include such topics as basic optics, imaging, perception, color, and polarization. Nine laboratory lessons are coordinated with the DVD lectures. Each lesson and lab requires extensive homework that is submitted over the Internet using the LONCAPA software that the department has been using for several years. The LONCAPA, which can be accessed from any computer linked to the Internet, handles the grading. The software also provides a unique communication link between instructor and students that allows for questions to be asked and answered and shared with others. Testing and examinations are taken with the same system, but students are required to go to special locations where they can be proctored.

In addition to the DVDs, the LONCAPA, and lab kit, the students have the support of a textbook as well as copious hints and review notes on the class Web site. This new mode of delivery has allowed students from the Columbia campus and around the state access to a class that otherwise would not be available.



Edwin R. Jones recorded a series of lectures that form the core of PHYS 153 Physics in the Visual Arts.

Awards

Graduate Students

Haiyun Lu was appointed in fall 2005 the C.C. Royal Fellow by the Graduate Council Fellowship Committee.

Nathan Baltzell (experimental nuclear physics) received a Southeastern Universities Research Association (SURA)/ Jefferson Lab Graduate Fellowship for the 2005–2006 academic year.

Gabriel Saracila received the Graduate Student Teaching Award.

Clarisse Tur received the Graduate Student Research Award.

Undergraduate Students

Benjamin Fonville Garrett won the Victor Laurie Junior Year Scholarship.

Eugenia Lydia Senn won the College of Arts and Sciences Rising Senior Award in Physics.

Jae Jun Kim and **Yossef Korang-Beheshti** were the Nina and Frank Avignone Fellowship winners.

Joshua Paul Witthuhn won the Rudy Jones Physics Award.

Jae Jun Kim won the National Science Foundation (NSF) Graduate Research Fellowship, was included in *Who's Who among Students in American Colleges and Universities*, and earned the Outstanding Senior Award.

Joshua Samuel Hendrickson won the Phi Beta Kappa Freshman Scholar Award.

Experimental Nuclear Physics Update

The experimental nuclear physics group continues its vigorous research program in basic and applied nuclear physics with programs at three national laboratories. The group continues to grow with the addition of Professor Steffen Strauch. The experimental nuclear physics group includes six professors (Gary Blanpied, Chaden Djalali, Ralf W. Gothe, Barry M. Preedom, Steffen Strauch, and David Tedeschi), four postdoctoral research associates (Oleksandr Dzyubak, Jörn Langheinrich, Rakhsha Nasseripour, and Kijun Park), nine graduates students (Nathan Baltzell, Christine Gibson, Jeremy Johnson, Lewis Graham, Haiyun Lu, Vladimir Montealegre, Michael Paolone, Isai Sundararaman, and Zhiwen Zhao), and four undergraduate students (Oliver Gothe, Brandon Eubanks, Eugenia Senn and Detra Watson) engaged in experiments designed to improve our understanding of the core of matter—the atomic nucleus.

The Experimental Nuclear Physics Group consists of (front row) David J. Tedeschi and Ralf W. Gothe and (back row) Chaden Djalali and Steffen Strauch.

Strauch complements our studies of in-medium modification of nuclear properties and baryon spectroscopy, and he has research experience in few-body and low-energy nuclear physics. He conducted his research with unpolarized and polarized, electromagnetic, and hadronic probes at the S-DALINAC/Darmstadt, the National Accelerator Centre/South Africa, MAMI/Mainz, and the Thomas Jefferson National Accelerator Facility (JLab) Hall A and Hall B. He has played a leading role in experiments at MAMI and Jefferson Lab Hall A, which studied proton medium modifications. These experiments showed that the polarization-transfer ratio in the quasielastic 4He(e,e'p)3H reaction is different from the free value; that ratio is directly connected to the ratio of electromagnetic form factors. He is now spokesperson of a follow-up Hall A experiment E03-104 "Probing the Limits of the Standard Model of Nuclear Physics with the 4He(e,e'p)3H Reaction," which will run fall 2006. As a member of the CLAS Collaboration, Strauch studied helicity asymmetries in double-charged pion photoproduction. This is part of a major program in Hall B to employ polarization degrees of freedom in baryon spectroscopy. One of those upcoming experiments is E03-105, "Pion Photoproduction from a Polarized Target," of which Strauch is the lead spokesperson. The USC group is a main contributor to this program through these physics projects as well as through the ongoing participation in the design and construction of the polarized target.

Preedom and graduate student Christine Gibson continue their study of nucleon structure with polarized photons at the LEGS facility at Brookhaven National Laboratory. During the past year, development of our novel polarized HD ice target was completed, and a Time Projection Chamber capable of distinguishing positive and negative charged pions has reached the final stages of construction. Experiments with the new in-beam cryostat began in spring 2005 and experiments using the new Time Projection Chamber are planned for 2006. Their experiments are expected to be sensitive to the cloud of pions surrounding the three constituent quarks in the core of the proton and the neutron, i.e. the nucleon.

Astronomy Program

Professor Varsha P. Kulkarni, graduate students, and collaborators continued research in extragalactic astronomy and cosmology using optical, infrared, ultraviolet, and X-ray facilities. Our research is funded by the NSF and NASA and resulted in six refereed and three unrefereed publications within the past academic year, while three more submitted papers are currently being refereed. Spectroscopic and imaging observations of quasars were carried out with the Very Large Telescope (VLT) and the Magellan Clay Telescope in Chile, the Gemini-N and Keck telescopes in Hawaii, the Multiple Mirror Telescope (MMT) in Arizona, the Apache Point Observatory (APO) in New Mexico, and the Chandra X-ray Observatory. The goals of these observations are to measure element abundances, sizes, and star formation rates in galaxies giving rise to low and intermediate-redshift quasar absorbers and their implications for the chemical evolution of galaxies over the past ~10 billion years. More observations are also scheduled with the Keck Telescope, APO, and Chandra. We have also been awarded observing time on the Spitzer Space Telescope for mid-infrared quasar spectroscopy.

The Astronomy Group includes (front row) Joseph D. Meiring, Christina K. Lacey, and Lorrie A. Straka and (back row) John L. Safko, Leila K. Mizouni, Sara K. Schultz, Varsha P. Kulkarni, Soheila Gharanfoli, and Parker W. Page.

Graduate student Soheila Gharanfoli defended her Ph.D. thesis proposal on high-resolution imaging of quasar absorber galaxies with Gemini and is also working on spectroscopic identifications of candidate absorber galaxies using Keck data. Graduate student Joseph Meiring, also a Ph.D. candidate, has been working on the analysis and modeling of MMT and VLT quasar spectra for element abundance studies in the absorbers and on imaging studies for obtaining star formation rates. Graduate student Sara Schultz worked on analysis of APO images during the 2004–2005 academic year. Graduate student Lorrie Straka has just joined and is beginning to work on imaging analysis. Professor Kulkarni, with the help of graduate students Gharanfoli and Meiring, organized the fourth annual Meeting of the South Carolina Astronomers in Columbia in April of 2005. This meeting, funded by the USC College of Arts and Sciences, was very successful in bringing together most of the state's astronomy faculty and students and in stimulating efforts for statewide research collaborations. Professor Kulkarni presented three invited talks at the University of Chicago, Cerro Tololo Inter-American Observatory in Chile, and South Carolina State University. Conference presentations included two talks at the American Astronomical Society meeting in San Diego in January of 2005, a selected talk and a poster at the International Astronomical Union conference titled "Probing Galaxies through Quasar Absorption Lines" in Shanghai in March 2005, and presentations by Professor Kulkarni and graduate student Meiring at the South Carolina Astrophysics Meeting in April of 2005.

Professor Christina K. Lacey worked with four undergraduates and two graduate students in the 2004–2005 academic year on research projects. The undergraduates worked on an ongoing project to monitor radio supernovae at different radio frequencies using data obtained with the National Radio Astronomy Observatory's Very Large Array in New Mexico in collaboration with Dr. Kurt Weiler of the Naval Research Laboratory in Washington, D.C. The undergraduates' research results have been incorporated into several articles that are in preparation. Graduate student Leila Mizouni is working with Professor Lacey and collaborator Miller Goss of the Very Large Array in New Mexico on an exciting project that has revealed a thirty-year decline in the radio emission of an ultra-luminous supernova remnant in the nearby irregular galaxy NGC 4449. The thirty-year time span of the radio emission from this supernova remnant, one of the most luminous remnants known, constitutes one of the longest temporal histories of the radio emission from a supernova remnant and shows a remarkable decline attributable to a young supernova remnant! This work is part of a larger study investigating the radio emission of supernova remnants in nearby galaxies. Graduate student Sara Schultz has just started working on a related project to correlate optical spectroscopy taken at the 4m telescope on Kitt Peak in Arizona with Very Large Array radio images of supernova remnants in the nearby spiral galaxy NGC 6946.

Advanced Solutions Group

Dr. Joseph E. Johnson and his research team are using mathematical techniques of Lie groups and algebras to study network relationships and intrusions against networks. The purpose of his federally funded research is to show that entropy metric functions of an associated Markov process can be useful in practical intrusion detection environments. This could allow for faster discovery of malicious attacks against networks, system failures, or abnormal processes. Since July 2004 Dr. Johnson has presented his findings to a variety of audiences including an international conference in St. Petersburg, Russia, in September 2005. He also has been invited to join a NATO exploratory team, "Complexity and Scalability in C4ISR Systems," which includes scientists and researchers from around the world. Along with the staff of the Advanced Solutions Group and Complex Problems Group, Dr. Johnson will continue his research during 2006.

Alumni Information

Amita Raval, MS in Physics, 1989; Advisor: Frank T. Avignone III (Single Beta Decay—Neutrinos)

Amita Raval

I went on to obtain a Ph.D. in High Energy Particle Physics from Hamburg University in Germany. I conducted my Ph.D. research on the ZEUS experiment on HERA (Hadron Elektron Ring Anlage) at DESY (Deutsches Elektronen Synchroton). HERA is an electron probe as it collides electrons onto protons at a center-of-mass energy of about 318 GeV. Presently I am a postdoctoral student at Penn State University and still with the ZEUS experiment. Hence I continue to live in Hamburg, Germany.

Simply put, I love what I do. Last year I published a paper on a search for pentaquarks (PQ) in deep inelastic scattering events with the ZEUS detector and presented the results at ICHEP04 in Beijing. The topic of pentaquarks is of great interest to the HEP community right now because, well, if they do exist, this would be the first evidence of a five-quark (4 quark + 1 antiquark) state. The topic is also controversial because whether pentaquarks exist is debatable. There are about as many experiments that claim to "see" this particle as those that don't. So it's a hot topic!

As for my personal life ... well, I live in Hamburg and am learning German. I travel extensively, both professionally and privately. I enjoy the European lifestyle and appreciate its progressive ways, but I definitely miss the United States, especially my family there. I have wonderful memories of my graduate days at USC. The convivial, fun, international atmosphere I experienced within the physics department is one that is not easy to find although, I must say, the ZEUS experiment provides a similar environment as it boasts about 400 physicists from about 35 different countries.… It's a fun environment as well! I also remember my professors James Knight, Frank Avignone, Horacio Farach, and Kuniharu Kubodera fondly. They played a major role in creating that atmosphere! And of course the secretaries as well, Lynn and Cheryl (who is no longer there, I believe).

Editor's note: Interested readers can find the pentaquark article by searching on SPIRES (www.slac.stanford.edu/spires/hep) with "find exp ZEUS and t narrow (or resonance)."

Astroparticle Physics Group

This group has three faculty members, Professors Frank T. Avignone, Richard J. Creswick, and Horacio A. Farach, and four graduate students, Domingo Ricardo Artusa, Iulian Bandac, Todd Hossbach, and George King. This experimental group concentrates on neutrino physics and cold dark matter candidates. These have impact on both elementary particle physics and cosmology. The current experimental emphasis is on the search for neutrinoless double-beta decay with a lesser emphasis on a search for hypothesized elementary particles called axions generated in the sun.

The existence of axions would explain a most important puzzle in particle physics, namely, why is it that the large violation of Charge-Parity (CP) symmetry predicted by quantum chromodynamics (QCD, the theory of strong interactions) is not found in nature at a level 10^{11} lower than the QCD prediction? The most promising explanation was introduced by Helen Quinn and Roberto Peccei, but, to be confirmed, a Goldstone boson called the axion would have to exist. Part of the group participates in the CERN Axion Solar Telescope (CAST) experiment in Geneva Switzerland. The first sensitive but null results were recently published *(Physical Review Letters*).The data place very tight constraints on the mass and coupling strength of these elusive particles.

The main effort concerns the sensitive search for the exotic nuclear decay in which a nucleus changes charge by +2 by emitting two electrons in a beta decay process, but without the emission of two anti-neutrinos necessary to conserve lepton number. The theory is well developed and gives a one-to-one relation between the mass of neutrinos and the decay rate. A direct observation would establish that neutrinos are their own anti-particles, lepton number is not conserved, and a measurement of the half-life would determine the mass scale of the three neutrino flavors. These are all important issues.

We are involved in two next-generation experiments: the Cryogenic Underground Observatory for Rare Events (CUORE) and the Majorana project. A prototype experiment for CUORE, CUORICINO, has been operating in the Gran Sasso underground laboratory in Assergi, Italy. It has been taking data for more than one year and has provided a lower limit for the half-life for this exotic decay of 2×10^{24} years. CUORE will be 20 times as large and will have significant discovery power. Two students, Iulian Bandac and Ricardo Artusa, and Professor Avignone have spent many months at the Italian laboratory.

The other zero-neutrino double-beta decay experiment, called Majorana, is a large experiment searching for the exotic decay of germanium-76. It is a large expansion of the experiment IGEX (the International Germanium Experiment) headed by USC, which was one of the two most sensitive searches for Majorana neutrino mass ever done. Four of our students earned their Ph.D. degrees working on IGEX and related fundamental experiments. The USC group has an important leadership responsibility in Majorana, and Majorana has an important role in neutrino physics. George King is doing his Ph.D. research on the project; Todd Hossbach completed his master's research in June 2005 and is now in the Ph.D. program.

Both of these experiments are on the very cutting edge of fundamental particle physics and cosmology, and the USC group has key roles in both.

New Parents in the Department in 2005

Graduate students Pawel Morawiec and Soheila Gharanfoli gave birth to a baby girl, Sophia Yasmine Morawiec, this past year on January 22, 2005, at 12:24 p.m.; she weighed 5 pounds, 8 ounces, and her height was 19.5 inches.

Graduate student Isai Sundararaman and her husband, Annamalai Swaminathan, gave birth to a baby girl, Varsha Swaminathan, this past year on February 21, 2005, at 2:10 p.m.; she weighed 5 pounds, 4 ounces, and her height was 18.5 inches.

Administrative specialist Mary Papp and her husband, Rick, gave birth to a baby boy, William Charles Papp this past year on August 21, 2005, at 2:06 p.m.; he weighed 10 pounds, 6.2 ounces, and his height was 21.5 inches.

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to our interest in MINOS. The comprehensive data anticipated from MIPP will enable accurate models of the production of neutrinos from proton interactions in the MINOS primary target with substantial impact on systematic error in MINOS results.

In May and June 2005 MIPP acquired in excess of $2x10^6$ events with 120 GeV protons incident on the spare target, fabricated for MINOS. Before and after taking data with the MINOS target MIPP paired beams of various energies from 5 to 60 GeV with thin targets of liquid hydrogen and various light and heavy nuclei. The analysis of this cornucopia of data is now the major challenge for our small collaboration. Carl Rosenfeld and Tim Bergfeld, with assistance from Andrew Godley, Sanjib Mishra, Karen Wu, and Chris Kullenberg, designed, fabricated, installed, and commissioned the Time-of-Flight particle identifier for MIPP. Undergraduates Josh Hendrickson and Kevin Wilson have assisted with the data collection and analysis. For the next several months USC personnel will focus on calibration and on development of software for determining the species of secondary particles from time of flight.

Bergfeld, Godley, Mishra, Wu, and Kim continue their analyses of the voluminous data on neutrino-nucleus interactions compiled by the NOMAD experiment. Publications of these analyses are in preparation.

Quantum Leap

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