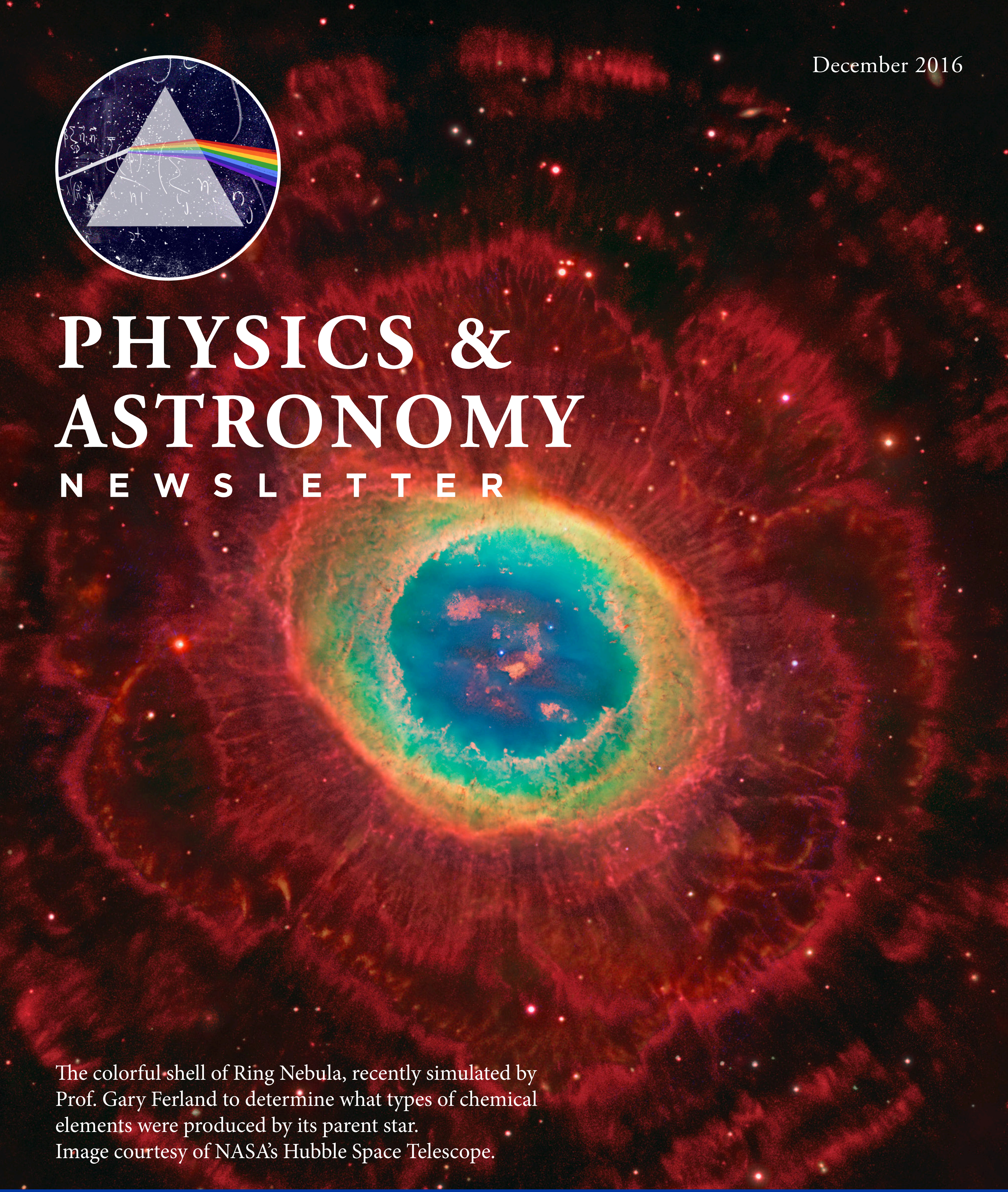
December 2016

PHYSICS & ASTRONOMY
NEWSLETTER



The colorful shell of Ring Nebula, recently simulated by Prof. Gary Ferland to determine what types of chemical elements were produced by its parent star. Image courtesy of NASA's Hubble Space Telescope.

University of Kentucky
Department of Physics & Astronomy
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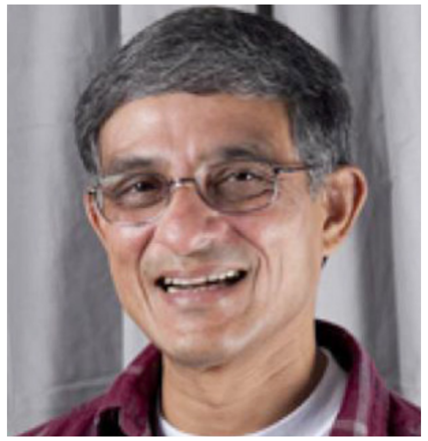
University of Kentucky
College of Arts and Sciences



Sumit Das

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(859) 257-1328

Greetings from the Chair

Our department witnessed an eventful year with new initiatives in research, teaching, and outreach missions. Prof. Gary Ferland received UK's highest research award, the Kirwan Memorial Prize, for his research in Astrophysics (p. 9), and Prof. Brad Plaster received the College of Arts & Sciences Innovative Teaching Award for his inaugural TEAL classroom (p. 4). At Commencement last spring, an Honorary Doctor of Science was awarded to one of our own, eminent astrophysicist David Arnett (B.S. Physics '61). Finally, we were deeply saddened to learn of the recent death of our former department chair, Keith B. MacAdam, who strengthened Physics and Astronomy at UK in countless ways over many decades. On p. 3 we highlight his career and the tremendous impact he had.

Other faculty, postdocs, and graduate students made important advances in our core research areas of Astronomy and Astrophysics, Atomic Physics, Condensed Matter Physics, High Energy Physics, and Nuclear Physics. Our faculty received a large number of federal grants, and many were invited to speak at major conferences and played leading roles in international collaborations. Colleagues from all over the world were welcomed as speakers in our department's colloquium and seminar series. In addition, well known statistical physicist John Cardy delivered the 2016 Van Winter Memorial Lecture, and Nobel Laureate Frank Wilczek delivered a public lecture.

In undergraduate education, we piloted an "active learning" version of introductory physics (PHY 211 and 213) in a technologically enhanced classroom (TEAL). The course was a great success—as described on pp. 4–5—and we hope to expand this initiative to include other introductory physics classes in coming years.

Our alumni provided much needed support to the department against a backdrop of state government cuts to higher education. Many contributed generously to the Physics & Astronomy Graduate Scholarship fund, providing a valuable means to attract top graduate students. Milton Huffaker (B.S. Physics, '57) continued to show his philanthropic leadership by supporting two crucial funds, one for graduate student scholarships and another for travel. Thanks to Milton's travel scholarship, Archisman Ghosh (Ph.D. 2012) was able to attend a conference that led to a change in direction in his research and his eventual participation in the discovery of gravitational waves, one of our field's biggest headlines in recent years.

As we continue to strive to reach greater heights, we would like to share our excitement with you. We hope the articles in this and upcoming newsletters will give you glimpses of our mission. And we would like to hear back from you with your suggestions and insights. We are planning to organize an Alumni day this spring and hope to welcome you back to the department.

Best wishes,
Sumit Das

In this issue:

We Mourn the Sudden Passing of Keith MacAdam

A pillar of Physics & Astronomy at UK, Professor Emeritus Keith MacAdam died on November 6, 2016, at the age of 72 after a brief acute illness. In the four decades since Keith first arrived in Kentucky, he strengthened our program in countless ways through exemplary teaching, research, service, and philanthropy, and his impact will be felt for many generations.

Keith B. MacAdam was born in Rochester, N.Y., attended Swarthmore College, earned a doctorate in Physics at Harvard in 1971, and came to UK as an Assistant Professor in 1977. He built a campus-based research program in experimental atomic-molecular-optical physics with students and post-docs, supported by the National Science Foundation and the Research Corporation. MacAdam's research was widely recognized in the international physics community, focusing on crossed-beam collisions between charged particles and laser-excited atoms in highly excited "Rydberg" states. He was elected a Fellow of the American Physical Society in 1987. At UK he taught students from first-year to graduate, and he introduced and taught for many years a popular non-majors' physics course, "How Things Work." He served as department chair in 1997–2001 and chaired the College Executive Committee in 2007–08, among many other committees.

Keith and his wife, Phyllis, helped create the MacAdam Student Observatory, which opened in 2008. He explained, "We won't duplicate the Hubble Space Telescope with an on-campus observatory, but this is your eye, receiving photons that have been on their way to you, for millions of years. Only you. You don't have to be a mathematician or physicist to understand and be fascinated by what's going on."

The MacAdams also established a Graduate Excellence Scholarship in Physics, currently held by Ph.D. candidate Jonathan D'Emidio, who commented, "I had the privilege of meeting Prof. Keith MacAdam just a month before his passing. I truly admired his passion for science and his drive to inspire younger generations of students at all levels. I have the honor of receiving the MacAdam graduate fellowship, which allows me to significantly advance my research in theoretical condensed matter physics and build the foundation of my future scientific career. Meanwhile, many more students have benefitted from the awe-inspiring view of the nighttime sky from the MacAdam Observatory. Gifts like these are invaluable to our department and they have an immeasurable impact on the students that they reach."

In 2014, Keith was inducted into the College of Arts & Sciences Hall of Fame and observed, "I think a liberal arts education is essential more now than ever, because we don't know what the future brings, we don't know the jobs that will develop, we don't know the challenges and the technologies that will exist. Only through a liberal arts education will we be prepared for the future."

While serving as a postdoctoral fellow in Stirling, Scotland, in 1971–73, Keith was drawn to the rugged mountains of the northwest coast of Scotland and returned many times with family and friends, most recently last June, to climb and photograph the peaks. A memorial service to celebrate his life will be held at a date to be announced.

Gifts in memory of Keith MacAdam can be made online at www.as.uky.edu/givetoas to the Physics & Astronomy Development Fund and may be designated for support of the MacAdam Observatory.

By mail, please send to:
University of Kentucky Gift Receiving
210 Malabu Drive, Suite 200
Lexington, KY 40502

If you have questions, contact Lisa Blackadar (lisa.blackadar@uky.edu) or (859) 257-8124.

TEAL Classroom Reinvents Introductory Physics at UK

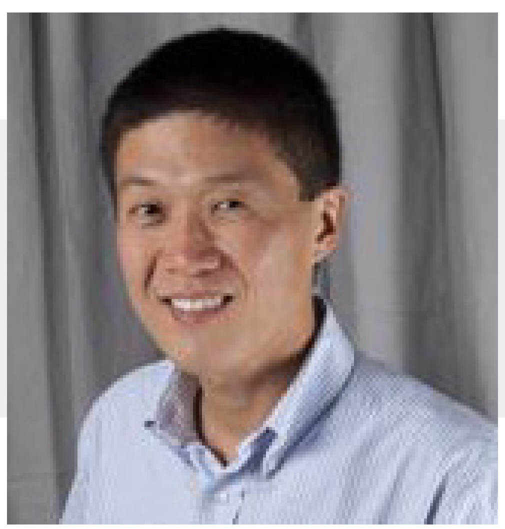
In recent years, a new approach to teaching introductory physics has been making news, showing promising results and earning rave reviews from students. For some time we have wanted to try out this new approach, known as Technology Enabled Active Learning, or TEAL. Last year, we got our chance, following the construction of a special-purpose classroom. This is our biggest new initiative in undergraduate education in many years, and the results so far have been spectacular.

TEAL is an approach to teaching based on the principle that students learn best from each other. TEAL employs a technologically enhanced classroom environment to facilitate interactions among students and between students and faculty. In a TEAL classroom, the instructor gives a short lecture to introduce concepts, which students immediately demonstrate and absorb through hands-on, interactive exercises and experiments. Students typically work at tables in small groups, facilitated by the instructor and assistants. Multiple video cameras and projectors make it possible for the instructor and students to communicate with each other, observe each others' progress, and share ideas and data from any part of the room. Each group uses a computer to collect and analyze data.

TEAL and related approaches were originally developed more than 15 years ago, as an alternative to the traditional large-lecture format of most introductory physics courses. Since then, TEAL has spread to other fields and has been adopted at a rapidly growing number of universities. A series of studies have demonstrated the efficacy of TEAL-like approaches in a range of introductory science and math courses, with significantly higher student performance and satisfaction as notable outcomes.

A major step in developing a TEAL course in introductory physics at UK was the construction of a special-purpose classroom. With support from the College of Arts & Sciences, a 54-seat classroom was built to our specifications just in time for the Fall 2016 semester. The classroom contains six 9-seat tables, each of which accommodates three groups of three students, and is equipped with state-of-the-art electronics, video, and communications technology.

While the classroom was under construction, Prof. Brad Plaster spent an intense semester and summer developing a TEAL version of PHY 211 and 213, a two-semester sequence of courses taken mainly by biology and health science majors. He observed TEAL classrooms at other universities, talked extensively with the instructors, and collected and incorporated their best practices. With the help of Teaching Assistants Alina Alexandrova, Danielle Schaper, and Mohsen Nasseri, Plaster designed, procured, and built a full set of hands-on exercises and experiments. He met regularly with a faculty committee to discuss ideas and issues associated with the development of the course. The course went live in Fall 2016.



Prof. Brad Plaster received the College of Arts & Sciences Innovative Teaching Award for his inaugural TEAL classroom.

PHYS 211 as conducted in our new Technology Enabled Active Learning (TEAL) classroom elicited outstanding evaluations from students and reversed a longstanding gender gap in performance on exams.

Students' end-of-semester evaluations were full of praise for Plaster and the TEAL format, and gave the course a higher overall rating than any other introductory level course we have ever offered:

- "This class was great. I love the TEAL version of physics. It made the class a lot more hands-on and easier to learn. I like how we work problems and worksheets in class every day. I also like the fact that the lab is integrated into the lecture."

- "Unlike other core science classes at UK, I really felt like the goal of this class was to help me LEARN physics and stimulate my interest in the subject rather than memorize it. Initially I dreaded the class, but the way it was presented and the way that the class was structured made me feel less intimidated. I felt like the group work really helped my problem solving skills."

This kind of response, for a rigorous, demanding, required course that is dreaded by many students, is extraordinary.

An even more startling outcome of the course was that female students significantly outperformed male students. The "gender gap" in traditional-format introductory physics courses is well documented, with most studies showing that men outperform women at a statistically significant rate. For example, when Plaster last taught PHY 211 as a large-lecture course, men scored an average of 4.7% higher than women on exams. This time around, the gap was reversed, with women outperforming men by 9.9%. Improvements in women's performance in a TEAL format have been observed in previous studies (though not to this degree), and have been attributed to the use of "interactive engagement methods that promote in-class interaction, reduce competition, foster collaboration, and emphasize conceptual understanding."

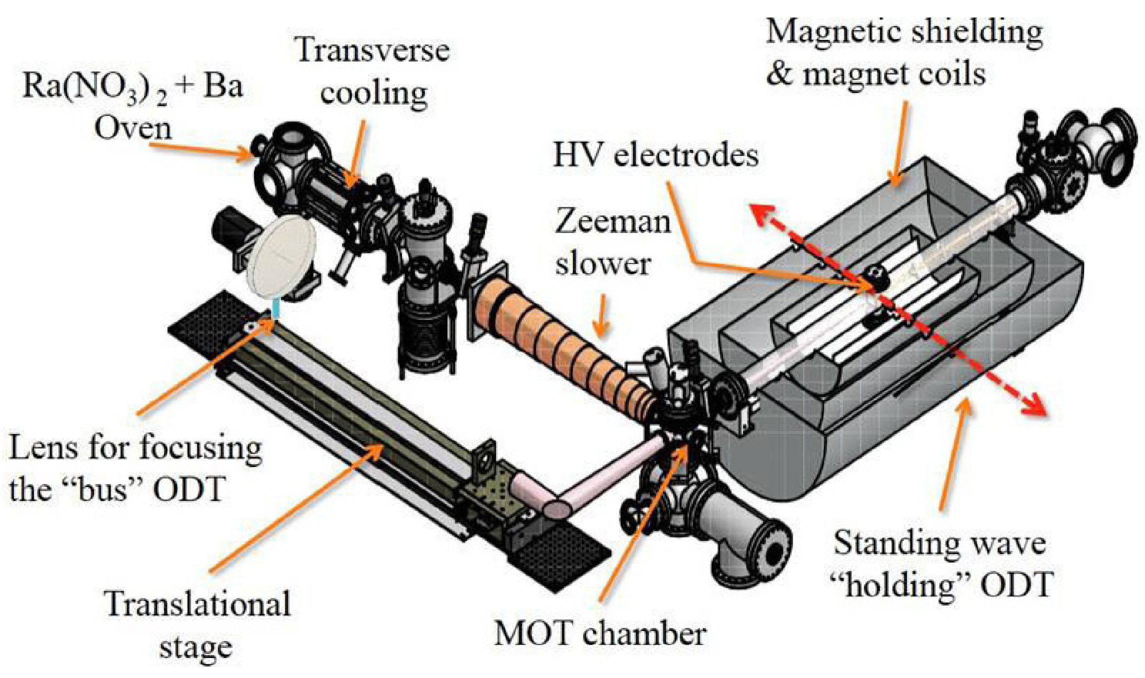
Last April, in recognition of his success in developing UK's first TEAL Physics course, Plaster received the Innovative Teaching Award of UK's College of Arts and Sciences. (He previously received the A&S Outstanding Teaching Award in 2013.)

This fall we are offering two sections of PHY 211, and hope to extend the effort to other 200-level courses in coming years. As other departments at UK develop their own TEAL-format courses, Plaster's PHY 211 will serve as a model, or perhaps as an ideal to which they can aspire.

Congratulations to Our New Ph.D.'s!

Mukut Kalita, Ph.D. '15
Advisor: Korsch
Field: Nuclear Experiment
Thesis Title: Search for a Permanent Electric Dipole Moment of 225Ra
Current employment: Post-doc, TRIUMF, precision atomic/nuclear physics

Mukut Kalita, working under Prof. Wolfgang Korsch's supervision at Argonne National Lab, extracted, for the first time ever, an upper limit on the electric dipole moment (EDM) of radium-225. The basic concept of the experiment is shown in the figure below. Atoms of radium-225 are laser-cooled to a temperature of about 45 μK and captured in an optical trap. They precess in a magnetic field while a strong electric field is applied. Any change in polarization which is correlated with the E-field direction would indicate the existence of a non-zero EDM; however, no such correlation was found, and Dr. Kalita was able to extract a first upper limit on the EDM of 5.0 x 10-22 e-cm, an important bound on possible time-reversal violating effects and on physics beyond the Standard Model. His work, published in Physical Review Letters, clearly demonstrated that modern atomic techniques can be used to probe physics at energy scales comparable to the particles produced in high energy accelerators. After defending his Ph.D. thesis, Dr. Kalita accepted a postdoctoral research position at the TRIUMF national laboratory in Canada where he continues to work on precision experiments using lasers and trapped radioactive atoms.



Schematic diagram of the experimental radium-225 EDM setup

Nandita Raha, Ph.D. '15
Advisor: Gorringe
Field: Nuclear Experiment
Thesis Title: Measurement of the dμd Quartet-to-Doublet Molecular Formation Rate Ratio (λq : λd) and the μd Hyperfine Rate (λqd) Using the Fusion Neurons from μ– Stops in D2 Gas
Current employment: INFN fellowship in Rome, Italy

Nandita Raha's dissertation research with Prof. Tim Gorringe was conducted with the MuSun experiment at Paul Scherrer Institute in Switzerland. The experiment is designed to the measure the absorption of negative muons by deuterium nuclei. The measurement of so-called μ–d capture permits the determination of the two-body weak nuclear force. In turn this enables the precise calculation of solar thermonuclear fusion, the reaction that powers the sun, and the neutrino-deuterium interactions responsible for solar neutrino oscillations. Dr. Raha was responsible for installing, calibrating, and operating the UK neutron detector array that enabled the measurement of several μ–d atomic and molecular reactions. Her dissertation research has provided the key reaction rates that are needed for the interpretation of the MuSun experiment and the determination of the two-body weak nuclear force. Dr. Raha now holds a prestigious International Postdoc Fellowship in experimental physics with the Istituto Nazionale di Fisica Nucleare (INFN) in Rome, Italy. She is working with several Italian groups on a precision laser calibration system for the muon g - 2 experiment to be conducted at Fermilab.

Zachariah Miller, Ph.D. '15
Advisor: Kovash
Field: Nuclear Experiment
Thesis Title: A Measurement of the Prompt Fission Neutron Energy Spectrum for 235U(n,f) and the Neutron-induced Fission Cross Section for 238U(n,f)
Current employment: Postdoc at UIUC with STAR collaboration

Zachariah Miller constructed, tested, and then used a novel layered scintillation detector to make the first low-MeV measurements of prompt neutrons emitted in neutron-induced fission of uranium-235, using the pulsed neutron beam at the Los Alamos National Lab. His instrument successfully reduced the detected backgrounds, exposing the relatively weak signal of fission neutrons. The excellent time and position resolution of the detector then allowed the fission neutron spectrum to be determined in the range from 0.5 to 3 MeV.

Dr. Miller is now a postdoc in the physics department of the University of Illinois at Chicago working on measuring bottom and charm (heavy) quark production in p+p, p+Au, and Au+Au collisions. The goal is to use the production of heavy quarks as a probe to study the Quark-Gluon Plasma (QGP), which is formed in Au+Au collisions but not p+p or p+Au, by comparing how the measured production rates change with and without the QGP present.

Elise Tang, Ph.D. '16
Advisor: Crawford
Field: Nuclear Experiment
Thesis Title: An Analysis of the Parity Violating Asymmetry of Polarized Neutron Capture in Hydrogen from the NPDGamma Experiment
Current employment: Postdoc at Los Alamos National Lab

Elise Tang, in her dissertation research with Prof. Chris Crawford, investigated the role that the weak force plays in the binding of protons and neutrons in the atomic nucleus. The weak force depends on the correlated distance between pairs of quarks inside protons and neutrons. It is about a ten-millionth of the strength of the strong force, and is very hard to extract from the strong force background. She did this using a unique property of the weak interaction: parity violation. To isolate this asymmetry between normal life and life as seen through a mirror, she measured a "left handed" signal from neutron capture on liquid hydrogen: the correlation between the spin of the neutron and the direction of the photon. Dr. Tang did her research with the international NPDGamma collaboration at the $1.4B Spallation Neutron Source at Oak Ridge National Laboratory in Tennessee. Taking data for two years at the highest flux neutron beamline in the world, she was able to measure the longest-range component of the weak force to a precision of one part in 100 million. Dr. Tang is now based at Los Alamos National Laboratory with her husband and newborn baby girl.

Patrick Hunley, Ph.D. '15
Advisor: Strachan
Field: Condensed Matter Experiment
Thesis Title: Synthesis, Integration, and Physical Charaterization of Graphene and Carbon Nanotubes
Current: Staff scientist, Cypress semiconductor corporation

Kyle McCarthy, Ph.D. '15
Advisor: Wilhelm
Field: Observational Astronomy
Thesis Title: Characterizing the Nearest Young Moving Groups
Current: Teacher at Troy Preparatory Charter School

Khayrullo Shoniyozov, Ph.D. '16
Advisor: Kovash
Field: Nuclear Experiment
Thesis Title: Elastic Compton Scattering from Deuterium Near 100 mev

Abishek Sundaraarajan, Ph.D. '15
Advisor: Strachan
Field: Condensed Matter Experiment
Thesis Title: A Study on Atomically Thin Ultra Short Conducting Channels, Breakdown, and Environmental Effects
Current: Staff scientist, Cypress semiconductor corporation

Hongwei Yang, Ph.D. '15
Advisor: Kovash
Field: Nuclear Experiment
Thesis Title: The N-P Scattering Cross Section from 90 kev to 1.8 mev
Current: Senior Software engineer, Brion Technologies, San Francisco

Hao Zhang, Ph.D. '15
Advisor: Brill
Field: Condensed Matter Experiment
Thesis Title: The Development and Implementation of Systems to Study the Physical Properties of Tantalum Trisulfide and Small-Molecule Organic Semiconductors
Current: Staff engineer, Alliance Fiber Optics, CA

Gary Ferland Receives Kirwan Memorial Prize

Prof. Gary Ferland has been awarded the 2016 Albert D. and Elizabeth H. Kirwan Memorial Prize, the University's highest honor for research. This award is given annually to one UK faculty member in recognition of outstanding contributions to original research or scholarship.

Ferland's research focuses on astrophysical applications of atomic and molecular physics; specifically, how matter in space produces the light we see. "We take the light that we can receive here on Earth and figure out what's happening out there," Ferland said. "Our computers here on the Earth allow us to run simulations to see how matter in space emits light, and what that light tells us about the galaxy." Simulations of this type were recently used by Ferland and his collaborators to analyze the colorful shell of the Ring Nebula (cover photo), in order to determine what types of chemical elements were produced by its parent star.

Ferland developed a computer platform, Cloudy, to simulate the effects of interstellar matter on astronomical observations. Cloudy is now one of the more widely-used theory codes in all of astrophysics. Cloudy was open source from its birth, allowing the astronomy community to improve and maintain it. "I started Cloudy in 1978 at Cambridge and my work on it has continued ever since," Ferland said. "It's completely open-source. As the atomic theory gets better, computers get faster, Cloudy gets better and is able to tell us more about what is happening at the edge of the Universe."

Ferland travels extensively—he spent last year as Leverhulme Trust Visiting Professor at Trinity College in Dublin—and has collaborators on several continents. "Astronomy today is so expensive that entire countries can't afford to purchase an instrument, like a deep space telescope, so researchers must be fiercely collaborative," Ferland said. "It's very liberating to be in Lexington and be able to telecommute with my colleagues across the globe."

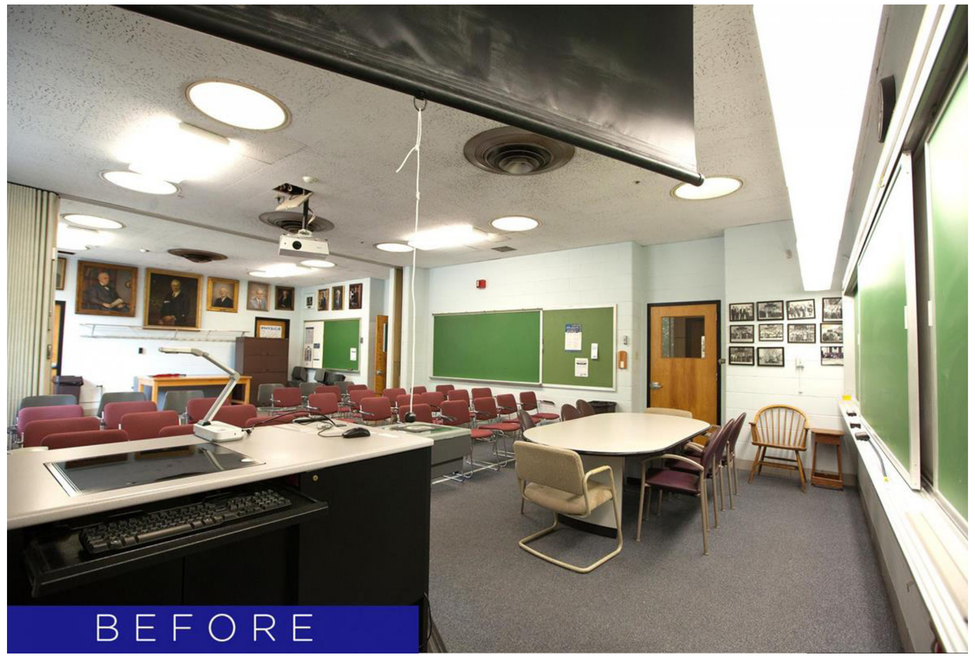
Recently, Ferland's team was awarded two high-profile research grants, from the National Science Foundation and NASA's Theoretical Astrophysics program, that will support their endeavors. These awards, amounting to more than $1 million, contribute to the theoretical calculations Ferland's group conducts here at UK.

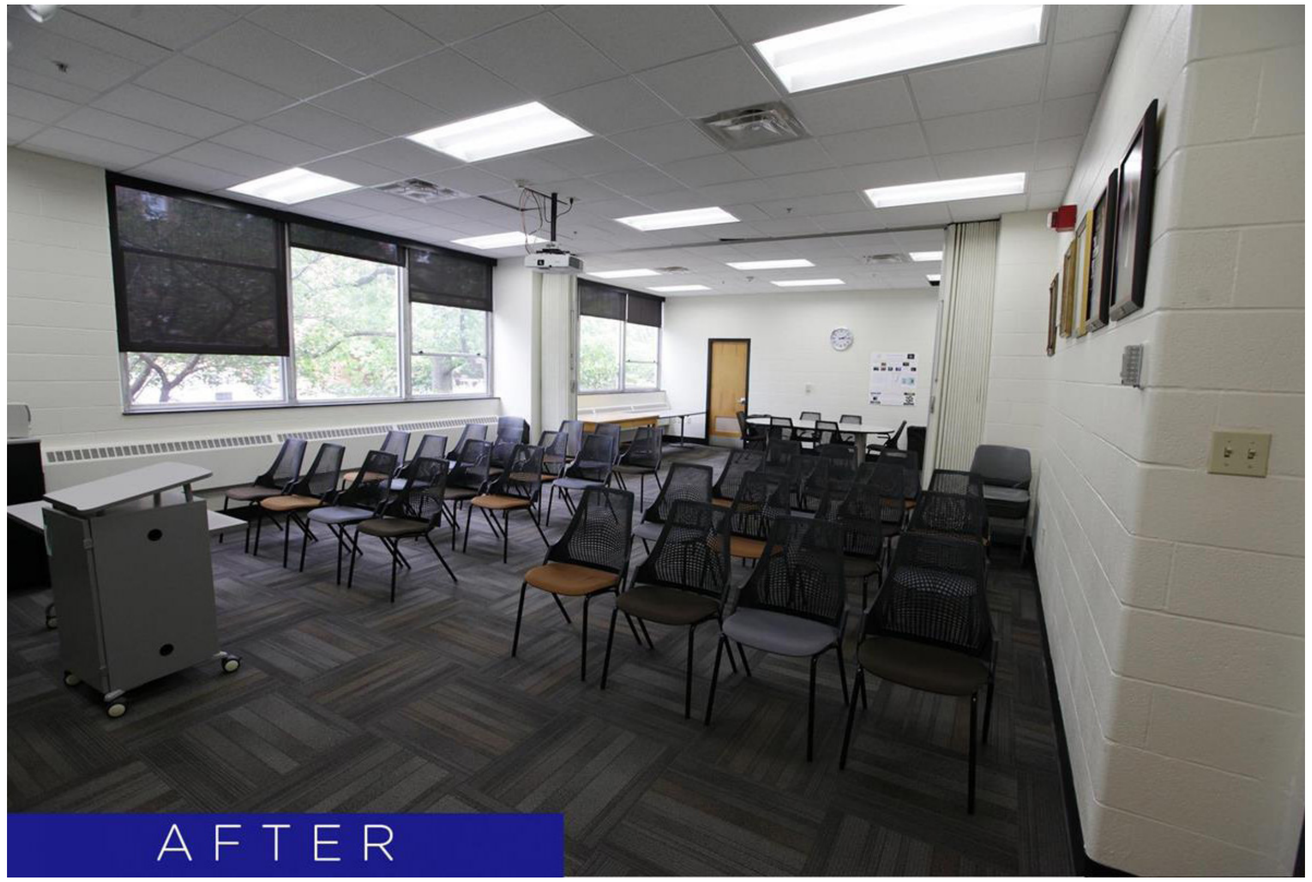
"Our department is fortunate to have him on our faculty," said Sumit Das, department chair. "He is currently the most highly funded faculty member in our department. He has trained a large number of graduate and postdoctoral students, and has contributed much to the visibility of our department."

Gary Ferland
Professor
gary@pa.uky.edu
291 Chemistry-Physics Building
(859) 257-8795

Chem-Phys Room 179 Renovation

A recent facelift to our conference room, Chem-Phys room 179, has energized everyone in our department who uses that space.





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For questions, please contact Lisa Blackadar (lisa.blackadar@uky.edu) or (859) 257-8124.

We are grateful for your support!