ΦYAST ΦLYER

The Homer L. Dodge Department of Physics and Astronomy
Volume 22, Number 1

Schwettmann To Join Department In Fall


Arne Schwettmann

Arne Schwettmann will join the department's atomic, molecular, and optical (AMO) group in August as a new faculty member. Arne earned a BS equivalent degree in physics from the University of Hannover in Germany in 2001, an MS degree in physics from the University of North Texas in 2003, and a PhD degree in atomic physics from the University of Oklahoma in 2012. For his doctorate research, he investigated Rydberg atoms of cesium and rubidium. Rydberg atoms are atoms in highly excited states with exaggerated properties. He proved the existence of long-range molecules formed by pairs of ultracold cesium Rydberg atoms over distances of several micrometers; built an atom chip apparatus for experiments with cold rubidium Rydberg atoms coupled to surfaces; and demonstrated a new sensitive quantum-assisted microwave sensor using Rydberg atoms. Since 2012, he has worked as a postdoc for Paul Lett in the Laser Cooling and Trapping Group of Nobel

(continued on page 15)

Milton's Paris Sojourn

Kim Milton received a prestigious Simons Fellowship to fund a sabbatical at the Laboratoire Kastler Brossel at the Université Pierre et Marie Curie during the 2013-14 academic year. There he worked with the quantum fluctuation group of Astrid Lambrecht and Serge Reynaud, perhaps the most distinguished group working on Casimir physics in the world. While there, he co-organized with Astrid a very successful international workshop on Casimir Physics at l'Ecole de Physique at les Houches, in the French Alps in April 2014, carrying on the tradition of the QFEXT meetings held biennially in the past, including in Oklahoma in 2003 and 2009.


Kim and Margarita during their visit to Monet's garden in Giverny.

While in Paris, Milton worked closely with Astrid and Serge, and with other members of their large group including Romain Guérout and another sabbatical visitor Gert-Ludwig Ingold, from the University of Augsburg. Two joint papers were submitted nearly simultaneously with Milton's return from Paris: Negative Casimir Entropies in Nanoparticle Interactions (K. A. Milton, Romain Guerout, Gert-Ludwig Ingold, Astrid Lambrecht, and Serge Reynaud) arXiv:1405.0311, submitted

(continued on page 13)

Greg Parker

From The Chair

by Greg Parker

This year we are excited to announce that we successfully recruited and hired two new faculty. An atomic, molecular and optical experimentalist, Arne Schwettmann will join our department this August. Nathan Kaib, a theoretical astrophysicist, will arrive in August 2015. Both Arne and Nathan are exceptional candidates, and we are delighted that they accepted our offers. In the past three years we have hired a total of nine faculty to strengthen our department.

In addition, our graduate recruiting committee admitted 22 new graduate students for the fall 2014 semester. That will bring the total number of graduate students in the department to more than 90, a 50 percent increase in the number of graduate students since 2009!

Over the course of the year, we lost the three valuable long-time members of the office staff, Danette Loyd, Sharon Widner and Debbie Barnhill, all of whom left for personal reasons. We are extremely grateful for their dedicated service for so many years. The temporary void was filled by Meagan Fulk, who was an exceptional temporary staff member for several months. She is now working in the College of Arts and Sciences Dean's Office. However, we are happy to announce that three excellent new staff members have joined us: Cynthia Pack (Managerial Associate and Assistant to the Chair), Rhonda George (Account and Budget Representative), and Joyce Hulin (Graduate and Undergraduate Programs Coordinator).

With the recent growth of our department, we are out of space in Nielsen Hall. We are working with the OU administration and donors to resolve this shortage.

Finally, we plan to organize an alumni reunion for this fall. We hope you will be able to attend and participate!

As always our faculty, postdoctoral fellows, staff and students continue to excel in research, teaching and service. We are indeed fortunate to have a collegial, prestigious and highly productive department. Our national and international reputation is increasing at a steady rate. We really appreciate all of our Board of Visitors, close friends and former alumni who are contributing so much to the success of our department!

The ΦYAST ΦLYER is the official newsletter of the Homer L. Dodge Department of Physics and Astronomy, College of Arts and Sciences, University of Oklahoma, and is published each spring by OU Printing Services at a cost of $1.70/copy to the taxpayers of the State of Oklahoma. The newsletter staff includes Dick Henry, Howard Baer, Deborah Watson, John Wisniewski and Bruno Uchoa. The University of Oklahoma is an equal opportunity institution. All photographs are by Robert H. Taylor unless otherwise noted.

Hats Off to Our Students!

Homer L. Dodge Departmental Awards

Dodge Outstanding Sophomore	Dodge Outstanding Junior	Fowler Prize
Joseph Altermatt	Hayden Nunley	Michael Reynolds

Physics and Astronomy Awards

Dodge Scholarship
Alex Dorio

J. Clarence Karcher Award
Zachary Eldredge

Duane E. Roller Award
Hunter Ash

William Schriever Award
Brandon Curd

Outstanding Graduating Senior
Bailey Bedford, Aaron Wegner, Catie Raney, Adrian Lucy

Karcher Scholarship
Anita Bhagat, Austin Burkett, Catherine Ciampa, Sagen Cocklin, Steven Hefner, Tarryn Kahre, Taylor Murphy, Hayden Nunley, Matthew Scheffler, Jacob Tice, Patrick Vallely, Li Yang, Kyle Yates

Webb Scholarship
Brandon Curd

Meritorious Scholarship
Joseph Altermatt, Hunter Ash, Jonathan Baldwin, Daniel Barhma, Nathaniel Beck, Bailey Bedford, Robert Alex Behlen, Christopher Bender, Jodi Berdis, Anita Bhagat, Jonthomas Box, Austin Burkett, Catherine Ciampa, Sagen Cocklin, Phillip Collins, Brandon Curd, Theodore Curtis, Daniel Dobrosky, Alex Dorio, Zachary Eldredge, Alex Garrison, Jeffrey Gillean, Forest Grayson, Steven Hefner, Jacob Higginbotham, Sam Jones, Tarryn Kahre, Rheannon Kickham, Stephen Lacina, Paul Little, Adrian Lucy, Neil McGlohon, Jamie Miller, Taylor Murphy, Hayden Nunley, John Pritchard, Josiah Purdum, Catie Raney, Michael Ray, Cody Ray, Michael Reynolds, Dillon Roberts, Vincent Rojas, Matthew Scheffler, Troy Southard, Brian Stephenson, Samuel Strother, Jeffrey Terry, Joseph Tessmer, Jacob Tice, Patrick Vallely, Aaron Wegner, Edward Wilkinson, Li Yang, Kyle Yates, Matthew Young, Conrad Young

Engineering Physics Awards

J. Clarence Karcher Award
Jacob Young

Duane E. Roller Award
Alec Forbes

William Schriever Award
Nicholas Kantack

Adams Scholarship
Brandon Carson, Mary Chenot

Karcher Scholarship
Trenton Hamm, Seth Hodgson, Madison Jones, Nicholas Kantack, Steven Roberts

Ruby Scholarship
Olivia Carutheres, Chuan Chin, Bao Tran

Alumni Scholarship
Timothy Corbley

Wilhite Scholarship
Jesse Harter

Outstanding Graduating Senior
Rachel Rogers

Meritorious Scholarship
Laura Anderson, Nathan Barry, Robert Beauvais, Brandon Carson, Olivia Caruthers, Mary Chenot, Chuan Chin, Timothy Corbly, Daniel Davidson, Daren Davis, Kevin Everly, Alec Forbes, Ryan Griffith, Daniel Grimmer, Trenton Hamm, Kendall Harper, Jesse Harter, Chase Hennion, Seth Hodgson, Madison Jones, Nicholas Kantack, Jeffrey May, Jocelyn Roberts, Steven Roberts, Omar Robles, Rachel Rogers, David Slemmons, Bao Tran, Jacob A. Young, Jacob D. Young

Graduate Student Award

George Kalbfleisch Memorial Award

Dan Mickelson

Graduate Degrees Awarded

Doctoral:

Kesheng Yang (Kao)
Prasas Maddumage Don (Wang)
Ayesh Jayasinghe (Gutierrez)

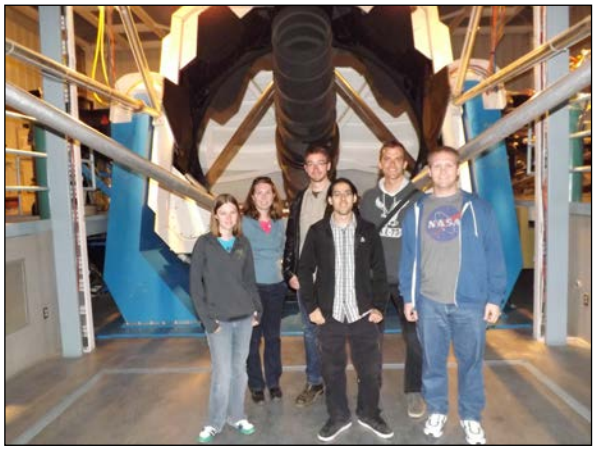
Masters:

Ailin Deng (Mullen)
Kuan Cheong (Mullen)
Paul Canton (Kilic)

OU-Apache Point Observatory Partnership

The University of Oklahoma signed a 3-year lease agreement with the Astrophysical Research Consortium in Sunspot, NM, giving its undergraduate students, graduate students, postdocs, and faculty access to research-grade 3.5m and 0.5m telescopes at the Apache Point Observatory. The agreement will help elevate OU's astrophysics research profile and provide invaluable educational training to OU students. After being trained to use these facilities on-site in New Mexico, OU astronomers will operate these telescopes from their offices in Norman. The first on-site training session happened on April 10-12; five OU graduate students and one post-doc are now certified as trained observers on the APO 3.5m and 0.5m telescopes. The first scientific paper incorporating data from OU's access to APO, "Evidence for AGN Feedback in the Broad Absorption Lines and Reddening of Mrk 231," led by Karen Leighly (and includes Eddie Baron and OU undergraduate Adrian Lucy as co-authors) is in press in the *Astrophysical Journal*, while another paper, "Near-Infrared Line Identification in Type Ia Supernovae During the Transitional Phase," led by graduate student Brian Friesen is in preparation.

Apache Point Observatory. Pictured left to right are the 0.5 meter telescope, the 2.5 meter Sloan Foundation Telescope, the New Mexico State University 1 meter telescope, and Astrophysical Research Consortium 3.5 meter reflector.



Pictured in front of the 3.5 meter telescope are (l-r) Malia Jenks, Jamie Lomax, Jeremy Lusk, Paul Canton, Brian Friesen and Tim Miller; all underwent instrument training in April under the leadership of John Wisniewski.

Wang Appointed Euclid Deputy Coordinator

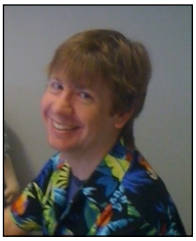
Euclid is a dark energy space mission led by the European Space Agency with NASA participation; it will be launched in 2020. Yun Wang was appointed the Deputy Coordinator of the Euclid Galaxy Clustering Science Working Group (one of the two primary Euclid SWGs). She will be working with the two coordinators (both European) in leading this group of over 300 scientists from around the world. This appointment makes Yun the second-highest-ranked American in the Euclid Consortium, second to the U.S.-led Jason Rhodes from NASA JPL.

Faculty Research Programs

Astronomy, Astrophysics and Cosmology

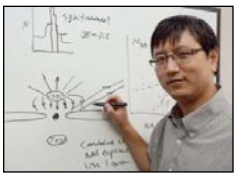
The **Supernova group**, headed by Eddie Baron, has grown and now consists of graduate students Brian Friesen, Jeremy Lusk, Malia Jenks and Cody Garges. Undergraduate Patrick Vallely recently joined the group. Brian is working on including the physics of late time pseudo nebular objects in the PHOENIX code framework. After many wrong turns, the group seems to be on the cusp of interesting results. Jeremy has been working on performing systematic models of Type II supernovae that should allow for a study of the wide variety of SNe II. Malia finished her specialist exam and began analyzing the time dependence of Type Ia supernovae spectra that are available in the exquisite dataset of the Nearby Supernova Factory. She is working in collaboration with OU graduate Sebastian Bongard who is at the University of Paris IV. Cody is busy with coursework but is writing a simple hydro code from scratch before moving on to work on time-dependent radiative transfer. The group has been well-represented at conferences: Jeremy, Malia and Eddie went to the Texas Meeting on Relativistic Astrophysics in Dallas, Texas, where Jeremy presented a poster. Brian went to the American Astronomical Society meeting in Washington, DC, where he presented a poster. Eddie gave invited talks at *45 Years of Nuclear Theory at Stony Brook: A Tribute to Gerry Brown*, Stony Brook University, and at the Carnegie Supernova Project II Workshop, Cook's Branch, Montgomery, Texas.

John Wisniewski's group consists of postdocs Jun Hashimoto and Jamie Lomax, graduate students Mike Malatesta, Evan Rich, and Steven Silverberg, and undergraduate students Jodi Berdis, Marcus Keil, Jamie Miller, Josiah Purdum and Matt Scheffler. Analyzing spatially-resolved imagery of young, potentially planet-forming disks continues to be a lead activity within the group. Hashimoto is leading the protoplanetary disk summary paper for the SEEDS survey, and Rich is working on publishing his analysis of the



John Wisniewski

DoAr 28 transitional disk imaged by the SEEDS project. Lomax is modeling the AB Aur protoplanetary disk system and analyzing HST coronagraphic observations of debris disks. The group also continues to study unresolved circumstellar disks, including mass transfer in interacting binaries (Lomax, Malatesta, Berdis, Keil, Scheffler), and disk-loss and disk-renewal events in classical Be stars (Wisniewski and former student Draper). In the realm of stellar astrophysics, the group contributed to analysis of the morphology of white-light flares from GJ1243 using the Kepler satellite (Malatesta, Silverberg, Berdis, Keil, Scheffler), and is leading the analysis of the flare energetics and frequency distributions from these data (Malatesta, Silverberg). Wisniewski's group was externally supported this past year by five STScI, one NSF, one NASA Origins of Solar Systems, and two NASA-Oklahoma Space Grant Consortium EPSCoR grants.



Xinyu Dai

Xinyu Dai continues to research astronomical objects such as gravitational lenses, galaxy clusters, active galactic nuclei and gamma-ray bursts. Postdoc Bin Chen is working on quasar microlensing, which provides a novel method to map the quasar accretion disk structure. Utilizing the dependence of microlensing variability on the source size, the group is able to resolve the disk structure that is several orders of magnitude smaller than the angular resolution of current telescopes. They recently received two large Chandra observing programs, in addition to Suzaku and HST observing time. Besides quasar microlensing, Bin also is interested in probing the interstellar medium of lens galaxies and exploring the embedded lensing model with Kantowski. Graduate students Jenna Nugent and Rhiannon

Continued on page 7

Research Programs (continued from page 6)

Griffin work on galaxy clusters, which are the largest gravitationally bound objects in the universe. They are ideal sites to constrain cosmological parameters and study structure formation. Rhiannon is working on the Swift soft X-ray serendipitous cluster survey and optical follow-up observations from MDM and NOAO. The survey has the potential to establish one of the largest X-ray selected cluster catalogs to date. In addition, she is placing tight constraints on the gamma-ray emission of clusters using Fermi data. Jenna is studying the missing baryon problem in the universe using Suzaku data. In addition, she is working on the Baryonic Tully-Fisher relationship. Active galactic nuclei (AGNs) are very energetic sources in the universe powered by supermassive black holes. Former MS and BS students Leah Moribito and Don Carmichael continue to work on the feedback process of AGNs to their host galaxies, properties of broad absorption line quasars, and the relationships between various AGN parameters such as the broadband spectral index, X-ray spectral index, luminosity, Eddington ratio, and variability with the aim to constrain AGN physics.

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Mukremin Kilic's group consists of postdoctoral fellow Alexandros Gianninas, graduate students Sara Barber, Paul Canton and Claudia Belardi, and undergraduate student Brandon Curd. Alex received Hubble and Spitzer Space Telescope time to solve the mystery of metals in extremely-low mass white dwarfs. Sara also received Spitzer Space Telescope and the 6.5m MMT time in 2013 and 2014 to image 100 massive white dwarfs to constrain the frequency of disks around these white dwarfs and the frequency of planets around their massive progenitor stars. Sara and Claudia used the CTIO 4m telescope over eight nights in February 2014 to search for transiting habitable-zone planets around white dwarfs. They obtained about 1.5 TB of data from this run. Alex and Paul continued to use the KPNO 4m telescope to search for short period binary white dwarfs and have identified several interesting systems. Brandon and Alex have identified several potential massive pulsating white dwarf stars, and observed a few of them using OU's share of the Apache Point Observatory 3.5m telescope. Brandon and Alex also are working on constraining the temperatures and ages of some of the oldest white dwarf stars known in the Solar neighborhood. Brandon was selected to attend the REU program at Cornell in the summer of 2014. Our group used Chandra X-ray observations to identify the first known progenitors of interacting AM CVn binaries and underluminous supernovae Ia explosions. This was featured in a Chandra image release. Mukremin, Alex, and other collaborators also identified a new 20-minute orbital period detached binary white dwarf system that is a verification source for future gravitational wave detectors.

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Yun Wang was appointed the Deputy Coordinator of the Euclid Galaxy Clustering Science Working Group (one of the two primary Euclid SWGs), which includes over 300 scientists from the world. Euclid is a dark energy space mission led by the European Space Agency with NASA participation; it will be launched in 2020. Wang is also a member of the Science Definition Team of the Wide-Field Infrared Survey telescope (WFIRST), NASA's next flagship space mission in astrophysics. She supervises one graduate student and an undergraduate student in cosmological research.

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Karen Leighly

Karen Leighly recently submitted a paper on the enigmatic quasar Mrk 231. This object has many unusual features including a broad NaID absorption line and unusually steep reddening in the UV bandpass. We could explain the unusually steep reddening by drawing an analogy with reddening seen in SN1a. If the dust screen has significant opacity and is spherical instead of a slab, blue light is scattered much more than red light, and the UV is strongly attenuated. A comparison of the optical and infrared absorption lines showed that low-ionization lines (NaID, CaII) had lower velocities than the high ionization lines (metastable helium: HeI*). Metastable helium must be produced closer to the central engine surrounding the black hole than the low-ionization lines. Photoionization modeling showed that the gas density in the partially ionized zone, where NaID is produced, must be higher than the density in the HII region,

Continued on page 8

Research Programs (continued from page 7)

and that the absorption occurred about 100 parsecs from the central engine. Interestingly, Mrk 231 is known to have a region of intense star formation about 100 parsecs from the center. We hypothesized that the starburst is the origin of the dust responsible for the unusual reddening. We suggested that the metastable helium absorption occurs in a wind emerging from the central engine that impacts upon, scoops up, compacts, and accelerates enriched gas from the starburst which in turn is responsible for the NaID absorption line. We asserted that if this interaction were not happening, no NaID line would have been seen. We are testing this idea by observing other similar objects to look for NaID absorption. The first observation using OU APO time was of SDSS J0300+0048 using the TripleSpec infrared spectrometer. We found no evidence for NaID in this object, supporting our hypothesis.

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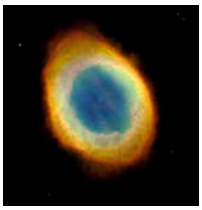
The **Gaseous Nebulae group** comprises doctoral student Tim Miller, undergrad Daniel Montoya, and faculty member Dick Henry. Tim has spent most of his time over the last year making use of the UV/optical spectroscopic data for the planetary nebula NGC 3242 recently obtained with the Hubble Space Telescope and the instrument STIS. Planetary nebulae (see image nearby) are low density gaseous clouds of material cast off during the final evolutionary stages of solar type stars. Determining the chemical abundances of elements such as C, N, and O in the gas provides important clues about the production rates of these elements by stars less than 8 solar masses. The project goal is to determine the role that these stars play in the cosmic production of carbon and nitrogen. Tim has reduced and measured the HST data, used software to compute the elemental abundances and calculated detailed photoionization models to study the distribution of these elements over the nebula to see if the elements exhibit a clumpy or homogeneous distribution. Thus far the evidence supports the latter. At the same time Dick has been using spectra for eight planetary nebulae from the same



The Ring Nebula

HST project to compute models of each nebula in order to confirm the properties of the dying remnant of the original star (the proto-white dwarf). Finally, as part of his senior capstone project, Daniel is learning the joys of modeling under Tim's and Dick's guidance by computing global models of NGC 3242 (in contrast to Tim's spatially resolved models). The project PI is actually Reggie Dufour of Rice University, but it has many important moving parts spread across the US. The OU group is essentially the theory team for the project.

Atomic, Molecular and Optical Physics

Deborah Watson has been studying large systems of cold fermions using a group theoretic approach to handle the very large number of interactions. These interactions can be quite strong, posing problems for theorists, since such systems typically do not have a natural perturbation parameter. Ultracold fermion systems have provided physicists with new systems whose interactions can be controlled with impressive precision, thus providing an important test of many-body theories. In particular, the unitarity limit where interactions become strong while the system remains dilute, has attracted much recent interest. In this regime, many properties of the systems become "universal" with the Fermi energy representing the only energy scale in the problem. The universal nature of the unitary limit gives it relevance to several areas of physics especially in condensed matter superfluid systems, cold dilute neutron matter such as found in neutron stars, as well as in cold Fermi gases.

The physics of large ensembles of fermions is especially challenging to describe, due to the Pauli principle which forbids two identical fermions from occupying the same quantum state. Enforcing the Pauli principle in a many-body calculation is typically time-consuming and thus quite expensive. The approach chosen by Watson and her collaborators uses mathematical techniques such as group theory and graphical techniques instead of computers to do the "heavy lifting." The Pauli principle is enforced "on

continued on page 9

Research Programs (continued from page 8)

paper," not numerically, thus allowing very large systems of particles to be studied economically.

Three students have been involved in this research over the past year. One of the students is attempting to use these methods to describe fermions in the nucleus of an atom while the other students have been studying large ensembles of cold particles in a gas. The goal for these large systems is to acquire insight into the transition from microscopic interactions to macroscopic behavior which has the potential to be technologically important.

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Jim Shaffer's research group had one new student, Jin Yang, and a postdoc, Jiteng Sheng, join the group this year, and they are looking for a few more students this year. Over the last year they published several papers, most notably in *Physical Review Letters*, but also a review paper for *Advances in Atomic, Molecular and Optical Physics* plus additional papers in *Optics Letters*. The group also presented invited talks at the Division of Atomic, Molecular and Optical Physics meeting of the American Physical Society and the ultracold Rydberg atom workshop in Dresden, Germany, at the Max Planck Institute for Complex Systems. Shaffer's group also received a new grant from the Army Research Office to upgrade their laser systems so that they can frequency-stabilize them to ultra-stable Fabry-Perot cavities. The group has some exciting results in the lab on trilobite molecules and atom-surface interactions, so stay tuned! The department hired a former student in the group, Arne Schwettmann, as a new faculty member in AMO, so the department is very proud of Arne. Shaffer also was named the Homer L. Dodge Professor of Atomic, Molecular and Optical Physics.

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Barbara Capogrosso-Sansone

Barbara Capogrosso-Sansone's research concerns many-body strongly correlated systems with an emphasis on ultracold atoms and molecules trapped in optical lattices. Barbara studies equilibrium properties of these systems by means of large scale, path-integral quantum Monte Carlo simulations. She is interested in developing algorithms, which can efficiently simulate exotic phases stabilized in these strongly interacting systems. She and her collaborator, Arghavan Safavi-Naini, recently have completed the development of several versions of a multi-worm algorithm, capable of simulating layered geometries of quantum particles interacting with long-range anisotropic interaction. An experimental realization of these systems consists of ultracold polar molecules, that is, heteronuclear molecules interacting via dipolar interaction. These systems promise to be a fertile ground for the study of novel exotic phases of matter. Another topic of interest concerns the study of quantum magnetic models. Spin hamiltonians can be mapped on to fermionic hamiltonians by using the so-called Popov-Fedotov trick. Through such a transformation, it is possible to study complex spin hamiltonians by using recently established Diagrammatic Monte Carlo techniques, where the sign problem is evaded, with the ultimate goal of studying complex quantum magnetic systems. Barbara's research group includes three graduate students, Wei Wang, Chao Zhang and Akbar Jahangiri Jozani, and one undergraduate student, Daniel Grimmer. Moreover, she enjoys close collaborations with colleagues in European and US institutions and plans to continue doing so.

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Greg Parker's graduate student Jeff Crawford and undergraduate student Zachary Eldredge developed a time-dependent hyperspherical coordinate method and associated numerical software for studying triatomic quantum reactive scattering. The time-dependent method offers an intuitive, physically meaningful picture of the reaction dynamics, as a wave packet can be observed as it propagates along the triatomic potential energy surface (PES). The use of wave packets provides information over a distribution of scattering energies for a single propagation in time, and as the wave packet returns to the product regions of the PES, "snapshots" are taken

Continued on page 10

Research Programs (continued from page 9)

at each time step to determine constituent final states. Using hyperspherical coordinates increases the computational efficiency. For three identical particles the triatomic PES becomes symmetric, reducing the amount of coordinate space required to represent the evolving wave packet. Reactive scattering results are important in the areas of combustion chemistry, atmospheric chemistry, ultracold dynamics, and trap loss in Bose-Einstein condensates. Jeff is enjoying his new job at Halliburton in Houston, Texas. Zachary Eldredge earned a B.S. degree in both physics and mathematics and is planning to attend graduate school at the University of Maryland.

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Since Neil Shafer-Ray passed away, **John Moore-Furneaux** has been continuing the precision molecular spectroscopy that Neil initiated. Efforts to complete the final experiment that Neil planned to measure the effects of the geometric phase on a beam of PbF as a preliminary step toward measuring the electron's Electric Dipole Moment, e-EDM, have been stalled while renovations on the PbF source are accomplished. Those are in their final stages and John anticipates starting up PbF experiments again by the end of the summer, 2014. In the meantime, the group has been measuring precision saturated absorption spectra of $^{130}Te_2$ in order to obtain more accurate molecular parameters for the B_0 excited state. These are generally important for the physics community as spectroscopic markers in the blue part of the spectrum. Until now only the ground and low lying excited states have been characterized precisely, to better than 10 MHz. Graduate students James Coker and David LaMantia, along with the undergraduate Jeff Gillian, have characterized over 4,000 lines. They are now are in the process of calibrating the absolute frequency of these lines to better than 10 MHz and fitting them to the model diatomic Hamiltonian to this same level of accuracy and precision. David and James are anticipated to graduate by the end of the summer.

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More than ten years ago, **Eric Abraham's** group published work on the creation of Laguerre-Gaussian (LG) laser modes using diffractive optics. These laser modes carry orbital angular momentum in addition to photon spin and are characterized by their toroidal intensity profile. Arguably, they were ahead of their time. The method of using diffractive optics is becoming a dynamic research field. The group has trapped ultracold atoms in these beams. Graduate students Tom Akin and Sean Krzyzewski developed a phenomenological model of the density distribution of the trapped atoms, and showed that it represented an *in situ* measurement of the mode quality of the beam.

Eric Abraham

Last year, Eric's group obtained the first data from a new experiment on Electromagnetically Induced Transparency (EIT) using LG beams in ultracold atomic vapors. EIT is an important effect in quantum optics with applications to optical computing. It uses a control laser to optically prepare a medium to be transparent to a probe laser. Led by Tom Akin, the group has observed EIT in both isotopes of rubidium using an LG beam as both the control and probe laser.

The group's final experiment is to study resonant collisions in ultracold gases and use these collisions to understand the interaction. Led by Sean Krzyzewski, they made improvements to their magneto-optical trap to implement sub-Doppler cooling and have attained temperatures around 20 micro-Kelvin. They have subsequently been able to transfer these atoms into another atom, based on a single focused, high-power laser beam. This second trap is required to be able to separately control the magnetic field to induce the resonances.

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Alberto Marino

Alberto Marino's interests lie in the field of quantum optics, with particular emphasis on quantum information and quantum metrology. After the initial setup of his lab last year, his group now has an operational source of highly

continued on page 11

Research Programs (continued from page 10)

entangled beams of light known as twin beams. The source is based on a four-wave mixing process in an atomic vapor cell. One of the particular properties of this source is the multi-spatial mode nature of the twin beams, which means that they contain spatial quantum correlations. Alberto and graduate student Matthew Holtfrerich currently are studying the properties of these spatial quantum correlations with the goal of controlling their distribution for quantum information applications. During the summer, Alberto visited the group of Dr. Jietai Jing at East China Normal University in Shanghai. During the visit they worked on both experimental and theoretical aspects of the generation of multi-partite quantum correlated beams of light. Alberto's group is also establishing a collaboration with Raphael Pooser from ORNL with the goal of interfacing the twin beams with plasmonic devices.

Condensed Matter Physics

In the last 12 months, **Bruno Uchoa** published one paper in *Physical Review Letters* and in *New Journal of Physics*. He also was the recipient of the NSF Early CAREER award, which will fund his research for the next five years. His theory group recently was joined by a new graduate student Miguel Rodriguez. Bruno was an invited speaker for the tutorial session in the 2014 APS March meeting and in the 2013 Midwest Solid State conference and presented talks in several research institutions in the US and in Europe. He has been working on different problems involving electronic strongly correlated systems. One of his recent works, which was submitted to *Physical Review Letters*, is about the role of disorder in the diffusive motion of electrons in metallic systems, which can localize. This property, known as Anderson localization, is nevertheless elusive in systems where the charge carriers propagate as massless Dirac fermions, due to the presence of fundamental symmetries such as chirality. Bruno and collaborators proposed a new kind of disorder that breaks that symmetry and turns out to be fairly common in graphene, an atomically thin sheet of carbon atoms. This disorder can produce an exotic and entirely new class of Anderson localization and could lead to the first experimental observation of Anderson transition in graphene.

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Kieran Mullen has been investigating the design of molecular sidechains to improve the flow of heat in and out of high thermal conductivity materials such as carbon nanotubes and graphene. This NSF supported work is a collaboration with Daniel Glatzhofer (OU Chemistry) who will work in synthesizing these materials and measuring their properties. In addition, he is collaborating with Glatzhofer and Uchoa (OU Physics) to understand the electronic properties of new possible allotropes of carbon, arrangements of carbon atoms that would have hitherto unseen band structures leading to novel transport behavior.

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Ian Sellers

Recently there has been exciting progress on several fronts in the PV materials group led by **Ian Sellers**. Their work on the role of nitrogen clusters in GaInNAs solar cells has led to the development of a selective passivation process that has been shown to reduce the role of defects in these materials. These findings, which have been investigated in collaboration with Amethyst Research Inc. in Ardmore, have the potential to significantly improve the performance of GaInNAs solar cells for utility-scale PV. His group developed a strong collaboration with Mike Santos' group with projects involving the development of intermediate-band quantum-dot solar cells in the InAs/GaAsSb system and hot-carrier effects in InAs quantum-wells. More recently Ian also has extended his research in developing hybrid colloidal QD solar cells, collaborating closely with the groups of Zhisheng Shi (ECE) and Lloyd Bumm here at OU. The progress in Ian's lab this year was further demonstrated by three oral presentations given by different members of the group (Vincent Whiteside, Miwa Fukuda, and Cheng Yang) at the American Physical Society meeting in Denver; in addition Sagen Cocklin gave a presentation at the Tulsa University Undergraduate Symposium.

continued on page 12

Research Programs (continued from page 11)

Active collaborations continue with several external academic partners including SUNY Buffalo, Tulsa University, TU Vienna, and CRHEA-CNRS in France.

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Sheena Murphy and **Michael Santos** have been collaborating on the new condensed matter field of topological insulators. Topological insulators are a recently discovered class of insulating materials that are topologically distinct from conventional insulators. Because of the topological nature, one cannot move continuously between a topological insulator and a conventional insulator (like vacuum) without crossing a non-insulating (i.e. conducting) phase; thus all topological insulators are bulk conductors with conducting surfaces. But these are no ordinary conductors − they are symmetry-protected, and hence they have potential applications as dissipation-less interconnects even in quantum computing. Reversing the typical order of condensed matter discoveries, topological materials were first theoretically predicted and then observed in the laboratory. There are now intense efforts world-wide to develop high quality topological insulator materials. Murphy and Santos have taken a different approach than most. Antimony (chemical symbol Sb) is a semimetal with the right band structure to be topologically interesting, although the bulk conduction precludes a topological insulator. Murphy and Santos are suppressing the bulk conduction via quantum confinement by growing ultrathin (1-3nm) layers of Sb by molecular beam epitaxy on GaSb substrates. The sample growth and fabrication is performed using the epitaxy and cleanroom facilities in Nielsen Hall, while the bulk of the electrical measurements are made at the National High Magnetic Field Laboratory in Tallahassee, Fla. The work is supported by the National Science Foundation.

Shayne Cairns, PhD candidate, at work at the National High Magnetic Field Laboratory.

High-energy Particle Physics

Phil Gutierrez

This past year, **Phillip Gutierrez** has continued participating in both the Fermilab D0 and CERN ATLAS collaborations. The D0 related work includes the measurement of the top quark mass in the all hadronic final state, which formed the basis of the dissertation of OU graduate student Ayesh Jayasinghe, who graduated in spring, 2013. In addition, Phillip received funding from Fermilab to support postdoc Peter Svoisky to complete two analyses that examine multi-parton interactions in proton anti-proton collision and to contribute to the measurement of the W boson mass. Phillip also has served on two editorial boards, one that reviews analyses pertaining to CP violation and the second that reviews the electro-weak production of the top quark. The ATLAS-related work includes both analysis and hardware contributions. With OU graduate student Ahmed Hasib, Phillip is performing a measurement of top anti-top quark production in the tau lepton plus hadronic final state. This measurement, which will form the core of Ahmed's dissertation, will be used to extract the relative branching ratio to this final state. It will be used to set limits on non-standard model decays of the top quark. In addition, with Ahmed and OU engineer Rusty Boyd, Gutierrez' group is performing some test on the ATLAS silicon pixel detector in order to improve its performance for future high intensity data taking. A second student, Qing Wang, has joined with Phillip to work on future top quark related analyses. At the present time, Qing is preparing for his specialist and finishing up course work.

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Patrick Skubic continues work on the ATLAS experiment at the LHC. He has been working with collaborators at OU and other institutions on measurement of the top quark pair production cross section in the tau-lepton + jets channel. The OUHEP group also has made progress contributing to construction of a new layer of pixel detectors that will be installed into ATLAS

continued on page 13

Research Programs (continued from page 12)

during 2014. The LHC will continue data-taking in 2015.

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Mike Strauss continues to do research with the ATLAS collaboration at the Large Hadron Collider. In 2012, a Higgs Boson was discovered at the LHC, yet many questions remain. Does this boson have the correct properties of the standard model Higgs? Is this one of a family of Higgs Bosons? Many theories, like supersymmetry, that extend the standard model of particles and fields, predict that other Higgs bosons should exist and can be discovered at the LHC. Strauss and his graduate student, Ben Pearson, are trying to answer these types of questions by looking for the decay of a Higgs boson to two W bosons which then decay to two leptons and two quarks. This is a decay mode that has not yet been seen at the LHC. It is quite challenging to observe due to extremely large backgrounds and the difficulty of triggering on events with this decay signature. Strauss and graduate student Callie Bertsche are using ATLAS data to measure the top quark mass from the top quark cross section. A precise measurement of the cross section of the top quark also gives a precise measurement of its mass since the two are highly correlated. The mass measured in this way is the so-called "pole" mass which is the fundamental mass of the top quark, independent of complications due to radiative effects.

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During the year 2013, **Howie Baer** has been working on his group's theory of radiatively driven natural supersymmetry. This theory reconciles electroweak naturalness with lack of SUSY signal at LHC while allowing for a 125 GeV Higgs boson. The main way to test the theory is to find the required light higgsino states at the proposed Japanese International Linear electron-positron Collider or ILC. He also has been working on the related dark matter theory of mixed axion-higgsino dark matter.

Milton (continued from page 1)

to JPCM special issue on Casimir forces, and Rigorous derivation of the Lifshitz-Matsubara sum formula for the Casimir pressure between metallic plane mirrors (R. Guerout, A. Lambrecht, K. Milton, and S. Reynaud) arXiv:1404.7633, submitted to Phys. Rev. E.

Kim's wife, Margarita Banos-Milton, was able to share the sabbatical, and they found an apartment in the heart of the Latin Quarter, 10 minutes walk to UPMC with a view of the towers of Notre Dame. Besides the wonders of Paris, they were able to visit Toulouse, the Loire Valley, Bayeux, Mont St. Michel, Trondheim, Chartres, London and Giverny, but they were able to barely scratch the surface of the culture of France. They are determined to return to try to fill in the gaps, with better French.

Howie Baer: Theorist of the Month

Howie Baer

Howie Baer, who is the Homer L. Dodge Chair in High Energy Physics, was appointed *Theorist of the Month* for March at the German National Synchrotron Laboratory in Hamburg. The Theorist of the Month is a concept installed in order to improve the exchange between theory and experiment and to strengthen the theory background of experimental PhD students. The Theorist of the Month typically spends about one week at the laboratory and in this time gives one basic seminar on his/her research topic; is available for all kinds of theory questions and discussions; and at the end of his/her stay summarizes the discussions and questions of the week. As March's Theorist of the Month, Howie presented a talk entitled: *Radiatively-driven natural supersymmetry with implications for LHC, ILC, WIMP and AXION searches*.

Summer Research for Undergraduates

Thirteen students from around the country as well as from OU will help conduct research in the department for two months this summer, thanks to the NSF-sponsored Research for Undergraduates program. The program is run by Eric Abraham. The students, home institutions and OU mentors are: David Campbell (U. Massachusetts Lowell, Shaffer); Sagen Cocklin (OU, Sellers); Christina Gilligan (U. Virginia, Kilic); Tarryn Kahre (OU, Leighly); Stephen Lacina (OU, Abraham); Abigail McBride (S. Nazarene U., Milton); Michelle O'Toole (Lehigh U., Marino); Nik Razo (East Central U., Baron); Matthew Scheffler (OU, Wisniewski); Moeko Tamura (Barnard College, Dai); Christopher Timms (UT-Dallas, Bumm); Josh Vilataro (OU, Abbott); and Danny Weller (Colorado Mesa U., Munshi). Two teachers also are participating in our NSF-sponsored Research Experience for Teachers program. The teachers, both working with John Wisniewski, are Kevin Warren and Eileen Grzybowski from Norman North High School. We welcome all of these students and wish them success in their summer work.

Astronomy Education and Public Outreach Activities

The astronomy group continues to expand their efforts to engage the broader community in education and public outreach activities. Graduate students Sara Barber and Jeremy Lusk were awarded one of two $10,000 Creativity in Motion prizes by the College of Arts and Sciences for their proposal to engage in astronomy outreach throughout the state. They will use the award to create a non-profit organization - the Lunar Sooners Foundation - that will fund and manage outreach activities including star parties, hands-on demonstrations and public talks to foster curiosity and an appreciation for science among students and interested groups in Oklahoma. Faculty members Wisniewski, Kilic and Dai, along with Norman North High School teacher Eileen Grzybowski, were awarded a $40,000 grant from the Space Telescope Science Institute to procure a mobile, digital planetarium (the "Sooner-tarium"). The mobile ~25-person capacity Sooner-tarium will be taken to local OKC-area high schools in the upcoming year, and select classes will be taught how to create their own planetarium modules to display in the Sooner-tarium, using the WorldWide Telescope software platform.

Take Us Out To The Ballgame!

For the fifth year in a row members of the department, including students, staff and faculty, attended the Oklahoma City Redhawks game on May 30. This year 54 people turned out to watch the Redhawks defeat the Omaha Storm Chasers 2-1, with the winning run being scored in the bottom of the ninth inning on a walk-off bunt! Attending as a large group means that each person receives a free Redhawks cap. In addition, the department's name was flashed across the jumbotron during the game, an obvious benefit for recruiting graduate students. Pictured at the left during last year's outing are physicist Jim Shaffer and son Jarek. Jarek is holding a ball caught by Andy Feldt as it came blistering into our section located along the left field foul line.

(Schwettmann continued from page 1)

laureate William D. Phillips at the National Institute of Standards and Technology (NIST) in Gaithersburg, Md. At NIST, he studied collisional spin dynamics of ultracold sodium atoms. In a Bose-Einstein condensate of sodium, spin-exchange collisions generate quantum entanglement between different atomic spin states. This entanglement can be utilized to build an atom interferometer with reduced noise compared to the standard quantum limit. As a new faculty member of the Physics Department at OU, he plans to start a research program in the field of ultracold atomic gases, with an emphasis on spin-changing collisions and other nonlinear quantum phenomena in sodium spinor Bose-Einstein condensates. This research has applications in creating massive entanglement useful for quantum computing, in demonstrating new types of matter-wave quantum optics devices such as a phase-sensitive amplifier for atom number measurements, as well as in the broader field of atomtronics, where neutral atoms instead of electrons are used as current carriers to power new types of quantum devices.

Note that a second new faculty member, theoretical astrophysicist Nathan Kaib, will be joining the department in fall, 2015. He will be featured in the newsletter next year.

2014 Faculty Awards

Howie Baer
George Lynn Cross Professor

Kieran Mullen
Regents Award For Superior Teaching

Barbara Capagrosso-Santone
A&S Junior Faculty Summer Fellowship

Xinyu Dai
A&S Junior Faculty Summer Fellowship

Alberto Marino
A&S Junior Faculty Summer Fellowship

Ian Sellars
A&S Junior Faculty Summer Fellowship

Eddie Baron
Most Inspiring Faculty Member,
Student Athlete Advisory Committee

Bruno Uchoa
NSF Early CAREER Award

Here we are!: Personnel of the Homer L. Dodge Department of Physics & Astronomy, 2013-2014

Please consider making a donation to the Homer L. Dodge Department of Physics and Astronomy

Your donations to our General Fund are used to support such critical departmental activities as physics and astronomy conferences on the OU campus, high-profile colloquium speakers, programs for women and minorities, outreach, alumni reunions, faculty and student research, postdoctoral fellows, graduate research assistants and newsletter publication. What you give to the department stays in the department.

To make a donation, go to www.nhn.ou.edu/donate/

Nielsen Hall, home of the Homer L. Dodge Department of Physics and Astronomy

Foucault pendulum, located in the Nielsen Hall atrium