

ΦYAST ΦLYER

*The Homer L. Dodge Department of Physics and Astronomy
Volume 20, Number 1*

Department Welcomes Two New Faculty Members



John Wisniewski

John Wisniewski (Astrophysics group) received his BS degree in astronomy-physics in 1999 from the University of Wisconsin and PhD degree in physics in 2005 from the University of Toledo.

Wisniewski was a NPP postdoctoral fellow at the NASA Goddard Space Flight Center's Exoplanets and Stellar Astrophysics Lab and a NSF Astronomy and Astrophysics postdoctoral fellow at the University of Washington. His research involves using multi-wavelength observational techniques to study the formation, structure and evolution of circumstellar disks, and searching for evidence of extra-solar planets in the youngest of these disks. Wisniewski's current research is centered on analyzing results

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Alberto Marino

Alberto Marino (Atomic & Molecular group) received his BS in Engineering Physics with specialization in optics and electronic systems in 1998 and a diploma in robotics in 1999 from ITESM

(Instituto Tecnológico y de Estudios Superiores de Monterrey) in Monterrey, Mexico. He began graduate studies at the Institute of Optics at the University of Rochester in 1999, where he earned an MS in optics in 2002 and PhD in optics in 2006 under the supervision of Carlos Stroud. His doctoral research specialized in the study and characterization of atomic coherent effects, such as electromagnetically induced transparency, and the generation of quantum states of light. Following his graduate studies he

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David Branch Attends Nobel Ceremonies

The 2011 Nobel Prize in Physics was awarded to Saul Perlmutter (Lawrence Berkeley Lab and Berkeley), Adam Riess (Space Telescope Science Institute and Johns Hopkins), and Brian Schmidt (Australian National University) for "the discovery of the accelerating expansion of the universe through observations of distant supernovae." Comparison of the apparent brightness of thermonuclear (Type Ia) supernovae in relatively nearby and very distant galaxies revealed that rather than decelerating

under the influence of gravity, the cosmic expansion appears to be accelerating owing to the existence of some unexpected agent dubbed "dark energy". Current data are consistent with dark energy being vacuum energy associated with a non-zero but preposterously tiny cosmological constant, although other possibilities including deviations from general relativity on cosmological scales are not excluded.

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From the Chair



Greg Parker

Unfortunately, Carl T. Bush – a personal friend and alumnus – passed away in May 2011. He visited our department often and communicated fairly regularly with several of us. We will miss his positive attitude and thoughtfulness as

well as his interest in the welfare of the department. Carl was very frugal and his desire was to give back to the department. His estate was sold this year which provided a significant endowed gift to our department. This gift is providing support for six endowed lecturers and library acquisitions. We sincerely thank Mr. Bush for this major gift and his friendship.

We also were saddened to learn of the passing of Norton Dodge, son of Homer L. Dodge and a major benefactor to the department, Nov. 5. Norton was a scholar of Soviet economics and a well-known collector of Soviet Underground art. His obituary can be found in the New York Times Nov. 13 arts section.

I am delighted to announce that in addition to hiring assistant professors Xinyu Dai, Mukremin Kilic, Barbara Capogrosso-Sansone, Ian Sellers and Bruno Uchoa last year, we hired assistant professors Alberto Marino and John Wisniewski this year. We are indeed excited to have these seven faculty join and strengthen our department. In addition, our graduate recruiting committee admitted 17 graduate students out of more than 180 applications.

Former alumni and Board of Visitor member A.T. Stair received the Distinguished Alumni Award from the College of Arts and Sciences. Professor

Michael Strauss was awarded a David Ross Boyd Professorship. Professors Lloyd Bumm, Mike Santos and Daminda Dahanayaka and Tetsuya Mishima received a Patent Award. Our financial staff person, Sharon Widner, received a merit award as well. Finally, Eddie Baron was made a Fellow of the American Physical Society *“for work at the forefront of computational astrophysics, especially for important contributions to the theory of core collapse supernovae and leadership in the theory of radiative transport in stars and supernovae.”*

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. We really appreciate all of our alumni who are contributing to the success of our department.

—Greg Parker

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Hats Off to Our Students!

Homer L. Dodge Departmental Awards

Fowler Prize

Logan Maingi

Kalbfleisch Prize

Kesheng Yang

Nielsen Prize

Chia-Hsun Chuang
Andre Lessa
Arne Schwettmann

Physics and Astronomy Awards

Dodge Scholarship

Stephen Holleman

J. Clarence Karcher Award

Thana-Nhan Do, Adam Fallon

Duane E. Roller Award

Stephen Holleman, Caleb Holt,
Savannah Logan, Michael Wilkinson

William Schriever Award

Bailey Bedford and Michael Reynolds

Outstanding Graduating Senior

Whitney Costello, Andre Goran and Jacob Stinnett

Karcher Scholarship

Austin Burkett, Don Carmichael, Catherine Ciampa, Zachary Eldredge, Savannah Logan, Adrian Lucy, Neil McGlohon, Michael Reynolds, Matthew Young

Dodge Outstanding Junior

Adrian Lucy

Dodge Outstanding Sophomore

Zachary Eldredge

Meritorious Scholarship

Hunter Ash, Nathaniel Beck, Robert Behlen, Christopher Bender, Ismael Beraza, Jodi Berdis, Anita Bhagat, Galen Buttitta, Dustin Clouse, Sagen Cocklin, Daniel Dobrosky, Kreg Flowers, Jeffrey Gillean, Kramer Harrison, Justin Hayden, Steven Hefner, Jeffrey Herring, John Hollrah, Stephen Kane, Sean Kavin, Andrew Meador, Anthony Meleco, Alexander Mutz, William Parker, John Pritchard, Michael Ray, Amanda Truitt, Brendon Watts, Aaron Wegner, John Weis, Matthew Wepel, Mallory White, Edward Wilkinson, Kyle Yates

Engineering Physics Awards

J. Clarence Karcher Award

Robert Free

Duane E. Roller Award

Jeshurun Chisholm & Chase Hennion

William Schriever Award

Jacob Young

Webb Scholarship

Chase Hennion

Adams Scholarship

Jocelyn Roberts

Meritorious Scholarship

Tyler Ashley, Arthur Bulin, Robert Bush, Becca Castleberry, Timothy Corbly, Kevin Everly, Alec Forbes, Brandon Hennessy, Seth Hodgson, Rachel Rogers, Derek Sealey, Nathan Sheely, David Slemmons, Seth Strout, Peter Tower

Karcher Scholarship

Nathan Barry, Dillon Carroll, Joshua Hardisty, Kendall Harper, Erik Holbrook, Nils Schlupp
Outstanding Graduating Senior
 Jody Bringhurst, Curtis Doiron and Scott Lowe



2012 student award recipients following the annual awards ceremony. Photo by Mike Santos

Distinguished Performance Award To Sharon Widner



Sharon Widner

Sharon Widner, the department’s account and budget representative, received a Distinguished Performance Award from the OU Hourly Employees Council during Staff Week in April. The award included a monetary prize. Since joining the department in 2006, Sharon’s main responsibility has been to manage all of the grant accounts, which total about \$4.5M. In this capacity, her efficiency, thoroughness and kindness in working with students and faculty are outstanding. Sharon’s monthly budget status report for each grant account is so clear that “even a physicist can understand it,” as one faculty member pointed out. Sharon is a tremendous asset to the department and contributes very positively to the work environment at Nielsen Hall. We congratulate her on her award!

Dissertation Defenders

PhD:

- Prachi Parashar (Milton)
- Mohamed Razzak Merra Lebbai (Skubic)
- Samanatha Gunawardana (Mullen)
- Chia-Hsun Chuang (Wang)
- Arne Schwettmann (Shaffer)
- Parshuram Dahal (Abraham)
- Dharshani Bopege (Furieux)
- Abdella Ait Moussa (Mullen)
- Dilhani Jayathilaka (Murphy)
- Tao Yang (Shafer-Ray)
- Roshan Bokalawela (Johnson)

MS:

- Henry Bradsher (Henry)
- Leah Morabito (Dai)

Alumni News



A.T. Stair

A.T. Stair (PhD Physics, 1956), a current member of the department's Board of Advisors, was recognized as a 2012 Distinguished Alumnus by the College of Arts and Sciences. This

honor is bestowed each year

on four graduates of the college who represent respectively the humanities, professional schools, natural sciences and social sciences. Stair was honored during a two-day series of events, February 23-24. On the 23rd, A.T. presented a department colloquium entitled "Fun With Physics: A Personal Odyssey." Stair was born in Oklahoma City, raised near Canton, Okla., and earned a degree in mathematics from OU in 1952 and a PhD in physics in 1956, the latter under the direction of Jens Rud Nielsen. He currently is president of Visidyne, Inc.



Andre Lessa (PhD Physics, 2011) was awarded the inaugural 2012 J.J. and Noriko Sakurai Dissertation Award in Theoretical Particle Physics by the APS. The citation reads: *"For outstanding research as graduate student and a dissertation that explores the cosmological consequences of solving the strong CP problem via the Peccei-Quinn mechanism in the context of supersymmetric models."* Lessa was born in Brazil and attended the Campinas State University, where he received his BS in Physics. Shortly after his graduation he joined the graduate program at the same institution, where he received his MS in Physics in 2007. In the same year he was awarded a four year Fulbright

Scholarship to continue his studies in the U.S. After attending one year at Florida State University, Lessa transferred to OU, where he obtained his doctorate in physics in 2011. During his graduate studies, Lessa published 13 papers on the phenomenology of supersymmetric models and axion cosmology and was awarded the George R. Kalbfleisch Scholarship for Academic Excellence in High Energy Physics Research from OU in 2010. Currently Lessa holds a post-doc position at the Sao Paulo University in Brazil, where he continues his research on supersymmetry at the LHC and axion physics. Lessa's OU advisor was Howie Baer.



Samuel Meek (BS Astrophysics, 2005) of the Fritz Haber Institute of the Max Planck Society, Berlin, was presented with the 2010 Otto Hahn Medal in June, 2011. Since 1978, the Max Planck Society has honored up to 30 young scientists and researchers each year with the Otto Hahn Medal for outstanding scientific achievements. The award citation reads:

"Dr. Samuel Meek is awarded the Otto Hahn Medal for the first-time realization of a miniaturized Stark decelerator on a chip. By depositing over one thousand electrodes on a glass substrate using lithographic techniques, he succeeded, using time-varying electric potentials, in creating electric field strength minima only microns above the surface and translating these with a well-defined velocity parallel to the surface. The field minima act as traps for polar molecules in a certain quantum state, and these molecules can be captured from a molecular beam, guided, and decelerated to standstill. The experiments presented in this work on the manipulation of polar molecules are an important first step in the realization of a laboratory on a chip." Meek finished his doctorate at the Fritz Haber Institute in 2010. The award will allow him to spend two years as a post-doc, and then set up his own semi-independent research group at the Max Planck Institute for 3+2 years. His plan is to "use a decelerator I helped develop during my PhD to decelerate molecules to low velocities and perform precision spectroscopy on them."

ALUMS AND FRIENDS OF THE DEPARTMENT: PLEASE LET US KNOW (rhenry@ou.edu) WHAT YOU'RE UP TO, SO THAT WE CAN INCLUDE THE INFORMATION IN A FUTURE EDITION OF THE NEWSLETTER!

Summer Research Experience for Undergraduates

Once again this summer, the department will host numerous undergraduates as they team up with faculty in their labs and offices to gain research experience. This year, we welcome 16 students, 10 from outside the department: Joseph Hart (AMO, Parker), Alexander Kerr (HEP/Astro, Baron), Kayla McMahon (AMO, Abraham), Daniel Marshall (CM, Santos), Amanda Tise (AMO, Abraham), Zachery Wheems (HEP,

Strauss/Abbott), Giulio Meille (HEP, Milton), Zoe Koch (CM, Bumm/Johnson), Nathan Edmonson (HEP, Milton), and Jimmy Wu (HEP, Milton); and six from within: Nathan Beck (THY, Milton), Dan Grimmer (AMO, Capogrosso), Ben Strickland (Astro, Kilic), Whitney Costello (CM, Bumm), Steven Ferguson (Astro, Kilic) and Peter Tower (AMO, Shafer). Edmonson and Wu are OSSM high school students.

Fermi Lab's Don Lincoln Conducts OSLEP Seminar

Since Kim Milton serves on the Oklahoma Scholars Leadership Program committee, he urged the members to invite a scientist to campus, so they charged him to find a suitable person. Kim invited Don Lincoln from Fermilab. Lincoln conducted a five-day seminar Oct. 19-23 titled "Tales from the Quantum and Cosmic Frontier," with 10 students, mostly but not entirely from OU, completing the seminar. Kim was the faculty resource person, which meant that

he attended nearly all of the class meetings and presentations, ate many lunches and dinners with the students, watched Nova videos with them, answered questions and provided resources, organized the public lecture Lincoln gave, and graded the final papers the students wrote. The seminar was quite successful in the view of most of the students, and in fact one of the students has apparently decided to become an astrophysics major as a result.

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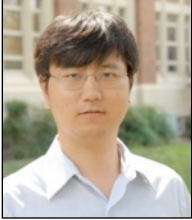
In December, my wife, Sheila, and I had the privilege of attending Nobel Week in Stockholm. A heavy schedule of receptions, tours, the Nobel lectures and other functions culminated in the formal presentation of the physics, chemistry, literature, medicine and economics prizes by King Carl XVI Gustav on Dec. 10 (always on Dec. 10, the anniversary of the death of Alfred Nobel). For me, having known the three physics laureates since they were grad students (at Berkeley, Harvard and Harvard, respectively), the highlight was to watch each of them flawlessly execute the traditional triple bow – to king, introducer and audience. At the banquet that followed, where

Sheila graced a new evening gown and I made my debut in rented white tie and tails, a multitude of young white-clad servers deftly presented a superb three-course meal (homard, pintade, mousse) to 1,300 people. That was a sight to behold, and we were left wanting to see the kitchen! To experience the banquet vicariously, view the time-lapse video at nobelprize.org. Click on "Nobel Banquet in Two Minutes." If the opportunity to attend Nobel Week comes your way, by all means seize it, as a once-in-a-lifetime deal. If you go as a laureate, though, be sure to get into shape. Your schedule will be positively grueling.

–David Branch

Research Programs

Astronomy, Astrophysics and Cosmology



Xinyu Dai

Xinyu Dai's research interests lie in understanding astronomical objects such as gravitational lenses, galaxy clusters, active galactic nuclei and gamma-ray bursts. Quasar microlensing provides a novel

method to map the quasar accretion disk structure. Utilizing the dependence of microlensing variability on the source size, he is able to resolve the disk structure that is several orders of magnitude smaller than the angular resolution of current telescopes. Bin Chen, a post-doctoral researcher, is working on this area under Xinyu's supervision. Galaxy clusters are the largest gravitationally bound objects in the universe. They are ideal sites to constrain cosmological parameters and study structure formation. Xinyu is currently working on the Swift soft X-ray serendipitous cluster survey. The survey has the potential to find one of the largest X-ray selected cluster catalog to date. He also is studying the missing Baryon problem in the universe. Graduate students Jenna Nugent and Rhiannon Griffin are working on these projects. Active galactic nuclei (AGNs) are very energetic sources in the universe powered by supermassive black holes. Xinyu is interested in the feedback process of AGNs to their host galaxies, in particular the kinetic feedback carried out by winds. He is working on measuring the intrinsic fractions of broad absorption line quasars of various species and the average absorption column densities of these objects. In addition, he also studies 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. Graduate and undergraduate students

Leah Morabito and Don Carmichael are working on these projects.



Eddie Baron was on sabbatical over the past year in Germany and Berkeley. During that time, Eddie's student Brian Friesen spent a month in Germany visiting Peter Hauschildt's group. Brian also attended the Computational Summer School in Berkeley last summer as well as the workshop on hydrodynamics at Georgia Tech in March 2012. Brian is second author on the first spectrum paper on SN 2011fe, a Type Ia supernova discovered only 11 hours after it exploded. OU student Jeremy Lusk has been working on SN 2000cb and Malia Jenks will join the SN group this summer. Postdoc Bin Chen has been working jointly with Xinyu Dai and Baron on relativistic radiative transfer. Bin is a co-author on a paper resubmitted and first author on a paper in preparation studying the effects of a Kerr Metric on the X-ray properties of AGN.



Karen Leighly and students have made significant progress in the past year. Karen was a prime driver in organizing a workshop titled "AGN Winds in Charleston." Approximately 100 scientists studying outflows attended. This event continued the AGN Winds sequence of workshops, the last one held in St. John in the Virgin Islands in 2005. Karen is an editor of the meeting proceedings, currently in press with the Astronomical Society of the Pacific. Data was collected for the He I* projects using the Large Binocular Telescope, the MDM observatory 2.4 meter telescope, the Gemini 8 meter telescope, and the Kitt Peak Observatory 4-meter telescope. Karen's OU undergraduate student Adrian Lucy reduced and analyzed the KPNO spectrum from

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FBQS J1151+3822. He discovered, in addition to the HeI* absorption, that there is MgII and FeII absorption in this object. These measurements have been important for further constraining the physical properties of the outflow. Adrian presented this work in a poster at the American Astronomical Society meeting in Austin in January. OU graduate student Erin Cooper has been working on HST data from a low-luminosity Seyfert galaxy WPVS 007. Previously, Karen discovered the emergence of a broad absorption line with maximum velocity of 6,000 km/s in FUSE spectra of WPVS 007 taken in 2003. The HST spectrum, taken in 2010, shows that the outflow is still present. However, the maximum velocity is now 11,000 km/s, and the profile suggests that acceleration has occurred. This has never been seen before; generally, absorption line variability is limited to changes in the optical depth with no changes in the velocity. This object also is unusual in that it has an anomalously low luminosity for such a high velocity outflow, and that it is an X-ray transient. It is possible that the object is undergoing a rare ejection event.



Dick Henry worked with collaborators Gary Ferland (U. Kentucky), Angela Speck (U. Missouri) and Amanda Karakas (Mt. Stromlo Obs.) on the “sulfur anomaly” in planetary nebulae, i.e., the unexpected finding that S abundances in these remnants of stars of 1-8 solar masses are systematically below expected values. Their paper concluded that the problem is due to the inability to adequately account for abundances of all ions of sulfur, when only S⁺ and S⁺⁺ abundances are measured directly. Dick’s PhD student Tim Miller and senior capstone student Mallory White began working on a project to measure abundances of C, O and Ne in metal-rich H II regions in the galaxies NGC 6822, M51, M83 & M101 using newly developed integrated field spectroscopy techniques. The three of them, along with Reggie Dufour (Rice), spent three nights in late April making

observations at the 2.7m telescope at McDonald Observatory. Graduate student Malia Jenks developed a program that allows a set of planetary nebula emission line strengths to be quickly matched to a specific model within a large grid of photoionization models covering wide regions of parameter space. Finally, masters student Henry Bradsher completed and defended his thesis on the chemical abundances in planetary nebulae located in the Small Magellanic Cloud.



John Cowan, retired since August, states that he is “continuing to publish, get grants and submit proposals - basically everything you guys do, except I do not get paid!”



Yun Wang is a member of the Euclid consortium. Euclid is an European Space Agency medium class mission selected for launch in 2019 in the Cosmic Vision 2015-2025 program. The main goal of Euclid is to understand the origin of the accelerating expansion of the Universe. See <http://www.euclid-ec.org> for more information.



Mukremil Kilic

Mukremil Kilic's group is making progress on a variety of topics in Galactic astronomy. Muk, graduate student Sara Barber and undergraduate student Adam Patterson have used NASA's

Infrared Telescope Facility and the Spitzer Space Telescope to constrain the frequency of debris disks around evolved stars. They find that at least 4 percent of white dwarfs have disks. Working with Patrick Dufour (U. Montreal), Muk used the Keck 10m telescope to study the chemical composition of some of these disks and showed that they are tidally disrupted minor planets and asteroids. Hence, the frequency of disks around white dwarf stars is directly related to the

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frequency of planetary systems around their progenitor stars. Based on this, Sara concludes that at least 4 percent of intermediate-mass stars have planets; a paper is ready for publication. This project also will form Patterson's capstone thesis. Muk and graduate student Paul Canton are leading the ELM Survey for short period binary white dwarfs that are strong gravitational wave sources and potential Type Ia supernova progenitors. Muk, Warren Brown (Smithsonian) and colleagues have identified double white dwarf systems with orbital periods as short as 12 minutes. He and his team are using Gemini and McDonald Observatory telescopes to measure the rate of period change in the shortest period systems to indirectly detect gravitational waves and to test Einstein's theory of general relativity. Muk and Paul are using the Palomar Hale 200-inch telescope to extend the ELM Survey to the entire area imaged by the Sloan Digital Sky Survey. Some of these systems show brightness variations due to tidal distortions and the relativistic beaming effect. Muk and undergraduate students Ben Strickland and Steven Ferguson are using high speed photometry to constrain the physical parameters of these binary systems. Muk, John Thorstensen (Dartmouth), Piotr Kowalski (Postdam), and graduate student Jeff Andrews (Columbia) have identified 11- to 12-billion-year-old stars only 100 light years away from us. These are the oldest stars in the solar neighborhood and they provide independent evidence that the Milky Way Galaxy is older than 12 billion years.

Atomic, Molecular and Optical Physics

Jim Shaffer: Two students from the Shaffer group graduated this year. Arne Schwettmann graduated in January and is now at NIST-Gaithersburg working with Paul Lett. Jonathan Tallant graduated in May. He is now working with Jim's longtime collaborator Luis Marcassa at the University of Sao Paulo. Arne was one of the students awarded the Nielsen Prize this year. Luckily, two new graduate students join the group this year: Haoquan Fan and Brittany

Pendleton, and a postdoc, Harald Kubler of the University of Stuttgart. They will have to work hard to make up for the loss of Arne and Jonathan. Jim's group also hosted several visitors. Luis Marcassa visited OU several times and Andre De Oliviera, University of Joinville, visited for a month, both from Brazil. During the past year, the group published several papers, most notably in *Nature Photonics* and a special issue of *Journal of Physics B* on Rydberg atom physics. They also received new grants from the NSF and Air Force for work on Rydberg atoms on atom chips. The atom chip work is just coming back online after the experiment was moved to a new room. With the grant the group received from DARPA last year, they were able to construct a new experiment on quantum assisted sensing of electric fields. They have several papers submitted on work related to this project, and they hope to have them published soon. They also were able to detect trilobite molecules in our Cs experiment over the last year. These molecules have the largest permanent dipole moments, ~30 Debye, observed for a diatomic molecule to date. Jim just submitted a paper on this work with collaborators Hossein Sadeghpour and Seth Rittenhouse of Harvard-ITAMP.



Eric Abraham.

Eric Abraham: Led by graduate student Thomas Akin, Eric's group completed its work on Bose-Einstein condensation transition calculations for atoms confined in Laguerre-

Gaussian laser modes (published in Jan. 2012 in *Optics Communications*). Former students Sharon Kennedy, Ben Dribus, Jeremy L. Marzoula, Lise Johnson and Jason Alexander also contributed to the work. Thomas Akin and Sean Krzyzewski now are working on studying ultracold collisions in rubidium gases. They have re-constituted the rubidium laser-cooled trap and are measuring numbers and densities in

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preparation for trapping the atoms in a dipole trap made from a single laser beam. Parshuram Dahal defended his thesis, *Progress Towards Producing and Trapping Cold Nitric Oxide*. He developed a new source of molecules for cold molecule experiments that can be used inside dilution refrigerators held at a fraction of a degree above zero that does not use laser ablation. This might be very useful because of the difficulty of optical access for dilution refrigerators. He also completed extensive simulations of a new system to trap cold nitric oxide, or any molecular radical with a similar ground-state structure.



Greg Parker

Greg Parker: Greg’s graduate student Jeff Crawford 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 that 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 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 currently is writing papers and his dissertation. He should be able to defend his research in late fall or early spring. Another graduate student,

Wei Wang, will take over this project in the fall, and he will add additional capabilities such as time-dependent electric fields, trap potentials and the ability to treat conical intersections. Juan Blandon has completed his postdoctoral work and currently is finishing a paper on ultracold dynamics.



Deborah Watson is pursuing the study of large systems of fully interacting particles using group theory instead of computers to do the “heavy lifting.” Describing fully interacting quantum wave functions is challenging, because the complexity of the problem scales exponentially with N , the number of particles. This typically requires doubling the number of resources for each particle added. With current numerical resources, this problem “hits a wall” around $N=10$ particles, a surprisingly low number. By taking advantage of symmetry, Watson’s group has successfully reconstructed this “exponential wall” using analytic building blocks. The exponential complexity has been shown to reappear in the order of the perturbation series, allowing calculations for very large N (a million or higher) through low order. Currently, the perturbation series can be determined analytically through first order, and an application to a Bose-Einstein condensate of rubidium atoms is in progress. A second-order term in the series is being pursued to obtain density profiles that remain positive for all radial distances. This term involves determining Clebsch-Gordan coefficients for the symmetric group that connect four different irreducible representations, a formidable challenge. The work on the second order term, which has involved both a postdoc, Martin Dunn, and a senior capstone student, Andrew Do, has been supported by the Army Research Office. A second project, an extension to large systems of identical fermions, also has been started which has required a major overhaul of the many-body formalism. Ultracold fermion systems provide new types of large interacting systems to study.

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Fermions are the building blocks of visible matter with a number of important systems, including nuclei, electrons in metals, superconductors, the quark-gluon plasma in the early universe, and white dwarf and neutron stars. Watson gave two invited talks on this work during the last year, one at the 242nd American Chemical Society National Meeting in Denver last August and more recently in the Department of Physics at the University of Connecticut in April.



Barbara Capogrosso-Sansone

Barbara Capogrosso-Sansone's research interests lie in the field of ultracold atoms and molecules. She has been interested in studying quantum

phases of many-body strongly correlated systems. Lately, her focus has been on polar molecules – that is, heteronuclear molecules interacting via long-range anisotropic dipolar interaction. These systems promise to be a fertile ground for the study of novel exotic phases of matter. The dipole-dipole interaction can be tuned and shaped via external static and microwave electric fields. A substantial part of Barbara's research is based on large-scale path integral quantum Monte Carlo. The method allows for exact treatment of bosonic hamiltonians. She currently is working on further developing the algorithm (which has already been successfully applied to study two-component systems and bilayers systems) to multi-layered lattice geometries with and without inter-layer tunneling. The anisotropic nature of the dipolar interaction allows for formation of filaments of polar molecules. Depending on the strength of the dipolar interaction (with respect to the kinetic energy) and the sample density, various quantum phases can be stabilized. This work is a generalization of a study carried out in a two-layer geometry.

Condensed Matter Physics

Mike Santos: Semiconductors are the basis for the fabrication of transistors and electronic components with key applications in modern life. The main activity of Mike's research group is the growth of semiconductor heterostructures by molecular beam epitaxy. The Santos group specifically is focused on narrow-gap materials for applications that would benefit from a high electron mobility, strong spin-orbit coupling, or an infrared band gap. During this past year, his group worked primarily on three projects with different sets of collaborators. With Sheena Murphy's group, they continued to study the effects of electron spin in InSb quantum wells and wires while searching for topological insulator behavior (a new fundamental property of certain materials where the electronic properties are protected by the laws of quantum mechanics against the effect of strong disorder) in various narrow-gap materials. With Rui Yang's group (Electrical Engineering) and Matthew Johnson's group, they demonstrated interband cascade lasers, detectors and photovoltaic devices with improved performance in the infrared portion of the spectrum. With Ian Sellers's group, they have begun to grow InSb quantum-dot structures for potential use in third generation photovoltaic devices. External collaborators include Yoshiro Hirayama's group at Tohoku University, Giti Khodaparast's group at Virginia Tech and scientists at Amethyst Research Inc. in Ardmore OK. Mike's projects are funded by the NSF, OCAST, AFOSR, DoE EPSCoR, and the Japan Science and Technology Agency.



Kieran Mullen has had two students earn their doctorates this year: Samantha (Harsha) Gunawardana, who is moving on to a postdoctoral research position at Iowa State University, and Abdellah Ait-Moussa, who continues as a faculty member at the University

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of Central Oklahoma. Both theses involved the transport of heat in carbon-based systems. The goal in this research is to design light-weight polymer composites incorporating graphene or carbon nanotubes to produce plastics that can readily conduct heat. Kieran also has started to collaborate with Ian Sellers on the study of quantum rings.



Ian Sellers

Ian Sellers: The last year has involved extensive development of the experimental capability in Ian's laboratory at OU. The equipment currently under construction includes various optical and optoelectronic capabilities, which offer the

ability to investigate semiconductor materials from the UV to IR, at low and high temperature, and at magnetic fields to 7 Tesla. The techniques available include photo and electroluminescence, absorption/transmission, photo-modulation spectroscopy, and PLE (amongst others). The recent delivery of a new optical-access superconducting magnet also allows the investigation of single semiconductor nanostructures. This system is predominantly designed for the investigation of semiconductor nanorings, and single magnetic quantum dots. In addition to the experiments already described, the laboratory also is fully equipped for solar cell characterization and photovoltaic materials development. These techniques facilitate Seller's research in next generation solar cells. Indeed, in the last year the Sellers' group has continued its very fruitful collaborative research programs with partners at University College London, Oxford University and SUNY Buffalo. As a result, articles have been published related to the viability of semiconductor quantum dots for photovoltaics (*Applied Physics Letter*, *Solar Energy Materials & Solar Cells*), along with work on the dilute nitrides for multi-junction solar cells (*Applied Physics Letters*).



Over the past year, **Bruno Uchoa** started his research group in Condensed Matter theory at OU. Uchoa's group has recruited Dr. Akbar Jaefari, from the University of Illinois at Urbana-Champaign, who will join OU in the fall as a postdoctoral research fellow, and graduate student Xu Dou, who will join the group in the summer. Uchoa has presented his work in the Kavli Institute of Theoretical Physics (KITP) in Santa Barbara, and was a chair of an invited session of the 2012 March meeting in Boston about strongly correlated electron systems. Uchoa has served as referee in many journals and also as a panelist for the NSF. In the past year, Uchoa published research papers in such journals as *Nature Physics*, *Physical Review Letters* and *Europhysics Letters*. Much of the focus of condensed matter research today is devoted to finding new quantum states of matter in a variety of materials. Bruno's group has been concentrating mainly in the physics of graphene, a two-dimensional allotrope of carbon made of a single atomic sheet of graphite, and also a new class of materials with many exciting properties known as topological insulators. Very recently, Bruno submitted a paper to *Physical Review Letters*, in collaboration with a group in Georgia Tech about the existence of topologically protected zero energy modes in graphene supported on Boron Nitride. Graphene is a metallic material with charge carriers that behave as massless Dirac fermions, which mimic the behavior of neutrinos. Although Boron Nitride (BN) shares a similar lattice structure to graphene (honeycomb-like), BN is a very good insulator. In this work, Bruno and collaborators have theoretically predicted that the BN substrate creates a real space pattern of zero energy modes in graphene in the form of quantum rings, containing fully localized states. These modes create a transport gap in graphene that can be tuned with the bias voltage, a key step for graphene-based applications in nanoelectronics. Uchoa's group also is currently working in the theoretical possibility of making

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graphene an intrinsic superconductor, a perspective that could revolutionize applications in this material.

High-energy Particle Physics

Brad Abbott's research has shifted recently to studying CP violation in b-physics at the D0 experiment at Fermilab. CP (Charge-Parity) violation says that a particle and its anti-particle can behave differently. For example, the rate at which a B^+ decays into a $J/\psi K^+$ can be different than the rate at which a B^- decays into a $J/\psi K^-$. We know CP violation is a necessary condition for our universe to form, since during the Big Bang equal amounts of matter and anti-matter were formed. Yet today, matter dominates over anti-matter. The Standard Model's prediction for the amount of CP violation is much smaller than what is necessary to explain today's universe. Therefore, unknown sources of CP violation must be present. A recent measurement at the D0 experiment at Fermilab has shown a discrepancy from the Standard Model's prediction and may indicate a new source of CP violation. Brad has been studying other methods to measure CP violation in hopes of finding additional evidence to support this discrepancy. In particular, two different decays of a B_s -meson have been studied: B_s decaying to $J/\psi f_0(980)$ and B_s decaying to $J/\psi f_2'(1525)$. These decays can provide insight into CP violation and will hopefully shed additional light on this interesting phenomenon. In addition to his work on D0, Brad has been active in the ATLAS experiment located at CERN. His graduate student Scarlet Norberg has been resident at Argonne National Lab for the past year on an Argonne Graduate Student Fellowship. Scarlet has been studying the photon cross section and recently presented her results at APS 2012. Brad also has been working with Antoine Marzin, a postdoc working with the OU HEP group, on searching for supersymmetry or SUSY. SUSY predicts that for every particle there is a super-symmetric partner, doubling the number of particles. After many searches, no evidence of any SUSY particles

have been found. However, due to the large dataset and high collision energy at ATLAS, stringent limits on many supersymmetric particles have been made, limiting the different possible SUSY models. The ATLAS detector is now collecting more data at a higher collision energy, so hopefully evidence of SUSY, or something else beyond the Standard Model, will be found soon.



In the past year, **Howie Baer** has published 15 articles on high energy physics. The LHC Atlas and CMS experiments gained some evidence in 2011 that the Higgs particle exists with mass 125 GeV. This has strong implications for supersymmetric models of particle physics, and favors a rather high squark mass scale, explaining why LHC has so far no sign of SUSY. The paradigm model for SUSY seems to be shifting from minimal supergravity to what is now called "natural SUSY" with a higgsino-like neutralino as a dark matter candidate. Howie's student Andre Lessa, post-doc Warintorn Sreethawong and Howie developed a new calculation of mixed axion/SUSY dark matter abundance using coupled Boltzmann equations. Andre graduated in August 2011, and he won the APS Sakurai prize for outstanding dissertation in theoretical particle physics (see *Alumni News* section).



Chung Kao

In the past year, **Chung Kao** studied the discovery potential of Higgs bosons and new strongly interacting bosons (colorons) at the early stage of Large Hadron Collider (LHC) as well as the LHC with full design energy. In addition, he investigated the implications of Higgs searches at the LHC for supersymmetric dark matter and presented talks at conferences in the United States, Sweden, Japan, China and Taiwan.

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During the past year, **Phil Gutierrez** has taken a sabbatical at Fermilab as a member of the D0 collaboration. He primarily has contributed to the study of the properties of the top quark, while leading the effort on two analyses, one in collaboration with OU graduate student Ayesh Jayasinghe, the second with a non-OU graduate student. Phil also has served on the review panel for D0 analysis on measurements on searches for CP violation in mesons containing b quarks. He also is starting a new analysis using data from the ATLAS detector at the CERN LHC with OU graduate student Ahmed Hasib. This will be a study of top quark production properties at higher energies and with a larger data sample that will allow the study of possible new physics.



The bulk of **Kim Milton's** research, and that of his group, continues to be on quantum vacuum energy phenomena, or the Casimir effect. Much of the work this year was on the Casimir-Polder force between an atom and a substrate, particularly exploring situations when that force becomes repulsive rather than attractive. For example, when a highly anisotropic atom is near a circular aperture in a conducting plate, on the symmetry axis and predominantly polarizable in that direction, it will experience a repulsive force due to fluctuations in the electromagnetic field. Kim and his student Elom Abalo also have been looking at new examples of exactly computable Casimir energies for cavities, which include certain tetrahedra and triangular prisms that had never been computed previously; the systematic behavior is quite remarkable. Elom will defend his dissertation on this subject this summer. They also have done some new work on unitarity in quantum electrodynamics and quantum mechanics in the PT-non-Hermitian formulation of the theory, which seems to put severe constraints on what is possible. Kim's interest in

magnetic monopole physics is reviving, due to several proposals for new experiments concerning the possible detection of magnetic monopoles at the LHC. New grants to support the work of his group came from the Julian Schwinger Foundation and the American Physical Society, supplementing the existing support from NSF and DOE, as well as earlier support from the European Science Foundation (that and the JSF grant have supported his former student, now postdoc Prachi Parashar). This summer Kim will also be working with at least one REU student, as well as two high school students from the Oklahoma School for Science and Mathematics. A highlight of the coming year will be his participation in a Casimir Summer School in Ushuaia, the southernmost city in the world, in October.



Pat Skubic

Recently, **Pat Skubic** has been working with his group on analysis of data from the ATLAS experiment at the LHC. Since he was on sabbatical for the fall 2010 and spring 2011 semesters, Pat was able to spend a lot of time at CERN during the last year working with post-docs Antoine Marzin and Muhammad Saleem who made major contributions to the analysis of ATLAS data. Two graduate students, Dilip Jana and Meera Lebbai, and programmer C. Walker also contributed to the data analysis effort. This work resulted in several papers and conference notes, including searches for supersymmetry (SUSY) and top cross-sections measurements. During this time, Skubic's group also has begun a very active collaboration between OU and OSU on ATLAS physics analysis and has initiated work on hardware R&D for an upgrade to ATLAS that is expected to be completed in 2014. Their hardware efforts have been coordinated by Electrical Engineer G. Boyd.

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Mike Strauss

During the last year, **Mike Strauss** has continued his research using the D0 detector at the Fermilab Tevatron. He served as the co-convenor of the D0 QCD (Quantum Chromodynamics) physics working group. In this position, he supervised and directed all QCD analysis within the D0 collaboration. The QCD working group is composed of about 40 graduate students, post-doctoral researchers and professors from all over the world who are using the D0 data to probe the properties and interactions of quarks and gluons. The last year has been the most productive year as far as peer-reviewed publications for the QCD group over the life of the D0 collaboration, with five publications, two in *Physical Review D*, and three in *Physical Letters B*. The published analyses have probed the substructure of quarks and gluons within the proton by looking at multiple proton interaction, and the production of three jet events. In addition, more research is being done on the production of jets plus bosons that can be used to look for physics beyond the standard model, but also is used for understanding backgrounds in more exotic decay modes. In the near future, Strauss will be moving the focus of his research from D0 to the ATLAS collaboration using the Large Hadron Collider at CERN. Two OU graduate students, Ben Pearson and Callie Bertsche, will be joining him to do research on ATLAS. The future research at the LHC looks extremely promising and exciting. The LHC is working wonderfully and will be running at a center-of-mass energy of 8 TeV. There are hints in the data that a future discovery of the Higgs Boson may be forthcoming. In addition, we hope that data from the LHC may begin to show physics not described by the

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from the Strategic Exploration of Exoplanets and Disks with Subaru (SEEDS), a large international collaboration that is using the 8.2m Subaru Telescope on Mauna Kea, Hawaii, to spatially resolve approximately 200 young, nearby circumstellar disk systems. Wisniewski and colleagues search for structures such as spiral arms, gaps and warps in these disks, which could be indirect signatures of the recent birth of extra-solar planets.

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held a postdoctoral position until 2010 and now is an assistant research scientist at the Joint Quantum Institute (NIST/University of Maryland), where his research has focused on the use of four-wave mixing in atomic vapors to generate and control quantum states of light known as twin beams. The use of an atomic system for the generation of these quantum states offers distinct advantages. First, it makes it possible to obtain a large nonlinear interaction, which leads to a large degree of entanglement without the need of a cavity. This makes the twin beams intrinsically multi-spatial mode, which means that they contain spatial quantum correlations in addition to temporal ones. Second, the use of an atomic system leads to narrowband entangled photons close to an atomic resonance. As a result, it is possible to obtain an efficient interaction between an atomic system and the entangled photons, which allows for better control. As a new faculty member of the Physics Department at OU, he plans to start a research program in the field of quantum optics, with particular emphasis on its applications to quantum information science and quantum metrology.

Teaching Scholar's Initiative

In October, Provost Nancy Mergler organized a Teaching Scholar's Initiative conference at OU. Kim Milton suggested a presentation on how he introduces and involves his students in research through thrice-weekly, several-hour research meetings including video links with remote students and collaborators, in which they not merely plan their research agenda, but carry out most of it. It is now Kim's laboratory. During the conference he described the success of this approach, which is pretty unusual in theoretical work. In addition, a YouTube video was posted which gives a small excerpt of his talk. Check it out at: <http://www.youtube.com/watch?v=2GcC330aCWY>

2012 Faculty Awards

Eddie Baron

Fellow, American Physical Society

Mike Strauss

David Ross Boyd Professor

Mike Santos and Lloyd Bumm

Patent Awards

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