Physics and Astronomy NEWSLETTER

October, 2010

FROM THE CHAIR

It is a great pleasure and honor to report on another year of remarkable growth and achievements of the Department of Physics and Astronomy. With over 32,000 students at MU this fall, we have fuller classrooms and labs in the Department than ever. We have a larger number of Physics & Astronomy majors, and more networked and active in the Department, than ever. This August, a record number of 12 new graduate students joined our Department. A total of 27 B.S., M.S., and Ph.D. degrees were conferred since August 2009. For FY 2011, the Department is looking at over $8 million in external grant funding. We are proud to be contributing to MU's advancement in ranking, with respect to federal research dollars, among the top 100 universities in the U.S. (only nine universities have advanced in ranking, over the past five years, by a larger quantum jump than MU), and to MU's recognition by the NSF as one of the nation's top 10 universities for successfully integrating research into undergraduate education. Generous gifts from our alumni and Physics Leaders provide support for departmental scholarships and professional growth. It is on this backdrop that faculty and students have excelled with a long list of achievements, awards, and honors. Some of these are highlighted in this newsletter.

It is a special honor to welcome Silvia Bompadre as a new faculty member to the Department. Silvia comes to us as an Assistant Professor in the area of biological physics, funded in part by the NIH award, "Hiring Plan for a Biological Physics Core Facility Position," announced in the Fall 2009 Newsletter. Silvia's research in molecular physiology and transmembrane channels adds important strength to our biological physics program, now at 8 core faculty members. She brings the total of full- and part-time faculty in the Department to 31 (including joint appointments in other departments), and the number of woman faculty to 10. In comparison, the national average of women faculty in Physics departments is less than 10%. An equally exceptional representation of women is noted among our graduate students: according to the American Institute of Physics, the MU Physics Department ranks among the top 10 departments nationwide that award more than 25% of Ph.D. degrees to women. Many movers and shakers have worked hard to help MU become more diverse. On October 21, the Mizzou ADVANCE Steering Board, of which Meera Chandrasekhar is a member, will receive the Mizzou Inclusive Excellence Award. Mizzou ADVANCE is an NSF-funded program to develop a more diverse senior faculty at MU by advancing women faculty in science, technology, engineering and mathematics. The Physics Department is very fortunate to have Mizzou ADVANCE and other advocacy programs for women and diversity on campus.

Faculty are putting the Department on the map by writing books. Wouter Montfrooij's book, "Excitations in Simple Liquids, Liquid Metal, and Superfluids" (Oxford University Press, 2010), with Ignatz de Schepper, just appeared. Sergei Kopeikin, Ioan Kosztin, Carsten Ullrich, and Giovanni Vignale are each writing a book, which will go to publishers in the near future. We bring the Department into the public eye with a new Physics Webpage developed under Dorina Kosztin's leadership; the Physics Facebook

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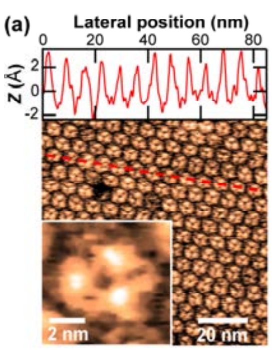
BIOLOGICAL PHYSICS at MU

A Careful Touch

by *Gavin King*
Assistant Professor, UMC

The atomic force microscope (AFM) – essentially a sharp needle affixed to a nanoscale robotic arm – has emerged as an important addition to the biophysicist's tool chest. MU's Precision Single Molecule Biophysics Laboratory, under the direction of Prof. Gavin King, has recently acquired a state-of-the-art commercial AFM. Utilizing this instrument, and in conjunction with a unique ultra-stable AFM currently under development, the King lab aims to elucidate membrane protein structure and dynamics in native biological settings (i.e., in fluid at room temperature).

Proteins are central to life. The ultimate goal of protein science is to be able to predict the structure and activity of a protein based on its amino acid sequence. While there have been significant steps forward in the field, predictive methodology has been hampered by the vast number of ways in which a protein can fold to occupy 3D space. Because they cannot be predicted, protein structures must therefore be determined experimentally. Major strides have been made in this endeavor through the application of techniques such as X-ray crystallography and nuclear magnetic resonance spectroscopy (NMR). Yet, for membrane proteins – a large class of proteins that exist as part of biological membranes – applying these traditional tools has proved daunting. Though they constitute ~30% of the proteins expressed in all cells, there exists a paucity of detailed information regarding their structure and dynamic configurations. This lack of knowledge is not indicative of a lack of importance. In fact, membrane proteins play many fundamental roles in the cell. Furthermore, they are anticipated to make up more than half of all future human pharmaceutical drug targets!



Molecular Resolution AFM Imaging of bacteriorhodopsin lattice recorded in aqueous buffer solution at room temperature. Inset: detailed view of a BR trimer showing sub-nm resolution.

Recent atomic force microscopy studies have established that membrane proteins can be imaged with sub-nm resolution in aqueous solution in their native phospholipid membranes. The King lab sought to compare the performance of their new commercial instrument to others around the world by imaging bacteriorhodopsin (BR), a model membrane protein. BR represents an ideal molecular benchmark due it robust crystalline nature. The resulting King lab data (shown in the figure) were promising. In particular, the 62 Å BR trimeric periodicity was clearly present (red line). Furthermore, quantitative analyses revealed features with approximately 5 Å lateral resolution, comparable to the best published images of which we are aware.

Our lab is currently employing its new force microscope to elucidate a ubiquitous but poorly understood

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Congressional Visit Day

by *Sashi Satpathy*
Professor, UMC

Prof. Sashi Satpathy visited Senator Kit Bond and other Missouri Congressmen in April in Washington, DC during the 2010 Congressional Visit Day on behalf of the American Physical Society to solicit the Congressmen's support for research in the Basic Sciences. The Congressional Visit Day is a two-day annual event that brings scientists, engineers, researchers, educators, and technology executives to Washington to raise visibility and support for science, engineering, and technology. Apart from Senator Bond, Sashi met with Senator Claire McCaskill and Congressman Blaine Luetkemeyer to discuss ways to enhance federal funding to support science in Missouri. Recently, Sashi was elected to a two-year term on the Executive Committee of the newly formed Prairie Section of the American Physical Society.

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biological process – protein secretion. Greater than 30% of proteins in any organism are exported from the site of synthesis into or through a membrane, yet many details underlying this dynamic process are not known. The general secretory or Sec system is the major route of export and the pathway through the membrane – the translocon – is provided by a protein complex, SecYEG. The King lab has recently acquired high resolution images of the translocon complex and are currently fine tuning our sample preparation and imaging methods for this delicate membrane protein system. Our investigations are broadly enhanced via a collaboration with Prof. Linda Randall (Biochemistry, M

Gaving King enjoying his time in lab

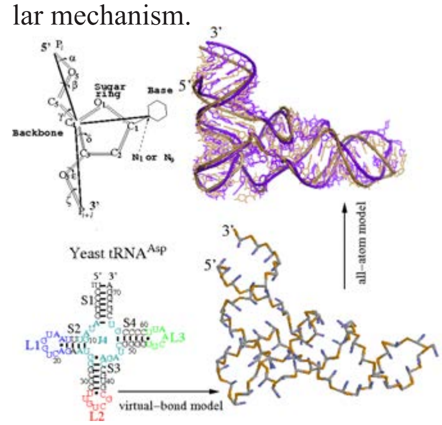
Physics-based Modeling of RNA Folding and Potential Therapeutic Applications

by *Shi-Jie Chen*
Professor, UMC

Based on rigorous physical principles, Shi-Jie Chen's lab is developing computational models to predict 3D tertiary structures, energy landscapes, and kinetic mechanisms for biologically significant Ribonucleic Acid (RNA) molecules. The current experiments on structural determination for RNA molecules cannot keep up the pace with the steadily emerging RNA sequences and new functions. This underscores the request for an accurate model for RNA three-dimensional (3D) structural prediction. Although considerable progress has been made in mechanistic studies, accurate prediction for RNA tertiary folding from sequence remains an unsolved problem. The first and most important requirement for predicting RNA structure from physical principles is an accurate free energy model. Recently, the Chen research group has made vigorous efforts in the development of a physics-based RNA folding model, where the original seven torsional angles for each nucleotide is reduced to three vectors. The unique model combined with a novel multiscaling strategy leads to a new physics-based theory for RNA folding. Benchmark tests indicate that this new model predicts RNA 3D structures with significantly improved accuracy.

In parallel to the theory development, the Chen lab is developing strategies to apply the computational models developed in the lab to a broad range of problems directly related to human health, including the rational design of anti-HIV RNA aptamers, quantitative understanding and predictions of retroviral frame shifting mechanism, and structure-based predictions for microRNA structure and activity. Recently, through collaboration with Dr. Paloma Giangrande's lab in the Department of Internal Medicine of the University of Iowa Medical School, the Chen lab is developing computational methods for the design and selection of RNA-based therapeutic strategies for cancer treatment.

Traditionally, it takes an experimental lab a huge amount of time and labor, with a lot of trial and error, search around for the correct molecular mechanism.



Flowchart for the prediction of all-atom 3D RNA structure from low-resolution 2D structures.

Now the structure prediction model developed in Chen's lab can potentially turn the search for the functional mechanism for RNA-based therapeutics into an efficient guided process. Therefore, if successful, such a computational method may significantly accelerate the process of design and selection of therapeutic aptamer.

Multiscale Modeling of Biomolecular and Multicellular Systems

by *Ioan Kosztin*
Associate Professor, UMC

Kosztin and his research group are developing and applying a variety of computational methods and theoretical models to investigate the physical mechanisms that underlie the functioning of different biological and biologically relevant systems, ranging from biomolecules to multicellular systems. The quantitative description of the properties of biological systems is extremely difficult because of their complex struc-

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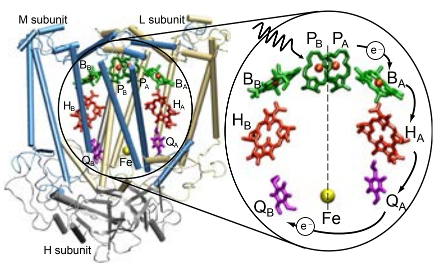
ture and dynamics that span a wide range of length and time scales. For example:

1) To study molecular and ion transport through channel proteins one needs to follow the dynamics of the system on atomic length scale (the length of the channel is ~4-5nm) and on macroscopic time scale (to ms) that is beyond the reach of current all-atom molecular dynamics (MD) simulations.



Structure of a famous pigment-protein complex: the photosynthetic reaction center (PRC)

Kosztin developed a successful approach to this inherently multiscale problem by modeling the diffusive motion of the particles along the axis of the channel as an overdamped Brownian particle in the presence of an effective potential of mean force (PMF), which describes its interaction with the rest of the system. Unlike other similar methods, Kosztin's approach (using a combination of nonequilibrium statistical mechanics and MD simulations) provides simultaneously both the PMF and the diffusion coefficient of the transported molecule. Using this approach, Kosztin predicted that, contrary to the general belief, in active cell membranes passive and spatially asymmetric channel proteins can in fact behave as active transporters by consuming energy from nonequilibrium fluctuations fueled by cell metabolism.

2) Another challenging quantum biophysics problem is related to light absorption by light-harvesting complexes in plants and photosynthetic bacteria. This is the first step in the vital process of photosynthesis. The Kosztin group developed a general approach that combines MD simulations, quantum chemistry calculations and quantum many-body theory for theoretically calculating and predicting the spectral and optical properties (e.g., linear absorption and circular dichroism spectra) of pigment-protein complexes of known structure. Remarkably the method requires as input only atomic-level crystal structure information.

3) Yet in another multiscale modeling effort, the Kosztin group, in collaboration with the Forgacs Lab, recently developed a computational-theoretical-experimental approach (called Cellular Particle Dynamics) that: (i) allows to predict the time evolution of 3D multicellular constructs, and (ii) permits to relate biomechanical properties at cellular level to those at tissue/organ level. This fascinating research project was very recently funded by an NSF grant.

Predicting Protein-Protein Interactions using the Principles of Physics

by *Xiaoqin Zou*
Assistant Professor

What causes the complexity and diversity of life? The completion of several genome projects, ranging from simple organisms such as E. coli bacteria and yeast to plants, mammals and humans, surprises us that an organism has quite a limited number of genes, suggesting that the

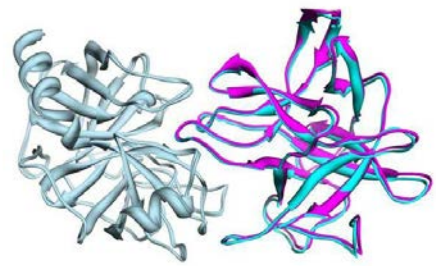
Recent Physics and Astronomy Graduates

Congratulations go out to the following physics and astronomy students who earned their degrees in the past academic year:

Bogdan Barz, PhD, "Theoretical and in silico modeling of biological systems: from protein structure prediction to cellular dynamics" (adviser Ioan Kosztin)
Adrian Corman, PhD "Carbon Stars and Silicon Carbide" (adviser Angela Speck)
Linghui Li, PhD, "Development of ZnO-based semiconductor photodetectors for UV detection" (adviser Ping Yu)
Shunlin Liang, PhD, "Probing Extragalactic Dust through Gamma-Ray Burst" (adviser Aigen Li)
Michael Kraus, PhD, Fundamental building blocks of nanoporous networks from ultra-small-angle X-ray scattering (USAXS) and smal-angle X-ray scattering (SAXS) experiments (adviser Peter Pfeifer)
Masters degrees were awarded to: Dan Caputo, Xiaolu Ma, Marcus Petrovic, Jimmy Romanos, Yiyao Chen, Bill Isaacson, Yonghui Li, Yuan Wang

complexity and diversity of life does not originate from the gene number. Instead, they come form the gene products – the proteins and their ability to communicate with each other and to assemble into larger functional units. Therefore, a predictive model for protein-protein interactions will have a far-reaching impact on understanding protein functions, cellular processes, and ultimately, the complex organization of life. Furthermore, protein-protein interactions play important roles in disease pathways. The ability to predict protein-protein interactions will provide valuable insights into mechanisms of disease pathways, identification of novel drug targets and rational therapeutic design. Despite significant advances in recent theoretical studies, a reliable and efficient computational model for protein-protein interactions remains at large.

Xiaoqin Zou, who joined the Department of Physics and Astronomy in January 2007 as an assistant professor, and her research group, use rigorous physical principles to develop novel computational models to predict how proteins bind to one other. One of the approaches is analogous to the inverse problem approach in liquid theory and uses statistical mechanics principals to decode microscopic interaction energy parameters from the energy landscape informa



Pictured is the comparison between the predicted binding mode (magenta) and experimentally determined crystal structure (cyan) for one of the complexes (Target 40) in the international CAPRI (Critical Assessment of Prediction of Interactions) competition. The complexes are aligned according to the binding partner protein (light blue).

tion encoded in many crystal structures of protein-protein complexes. Using the methods they recently developed, her team has participated in the highly competitive 4th international CAPRI (Critical Assessment of PRediction of Interactions) bi-annual competition on protein-protein complex structure prediction, and won the 3rd place in both the predicting and scoring categories. The team did not participate in the first several rounds. For the rounds that they participated, they achieved even better performance (1st place in scoring and 2nd place in predicting).

Based on the project on development of computational methods for predicting protein-protein interactions, Xiaoqin Zou has received a Faculty Early Career Development (CAREER) Program Award from the National Science Foundation in the amount of $734,016 for 5 years. This Award Program is part of the National Science Foundation that represents its most prestigious awards to support the early career-development activities of teacher-scholars who most effectively integrate research and education within the context of the mission of their organization.

Read more about the research conducted by our faculty on the web at: www.physics.missouri.edu

NSF Meeting on "Opportunities in Graduate Student Training in Neutron Scattering: Present Status, Needs, and Prospects"

by *Haskel Taub*
Professor, UMC

For the second year in a row, the Department of Physics and Astronomy has been invited to submit a full proposal to the Integrative Graduate Education and Research Traineeship (IGERT) Program of the National Science Foundation. Haskell Taub, our department's Director of Neutron Scattering, is Principal Investigator on the proposal entitled "Neutron Scattering for the Science and Engineering of the 21st Century." The proposal seeks funds to support a total of 20 graduate students over a five-year period in interdisciplinary research utilizing neutron scattering. It is being submitted in partnership with Indiana University, Fisk University, North Carolina State University, Oak Ridge National Laboratory (ORNL), and the National Institute of Standards and Technology (NIST) as well as neutron scattering centers in China and Italy.

In June 2010, Prof. Taub organized a meeting at the NSF entitled "Opportunities in Graduate Student Training in Neutron Scattering: Present Status, Needs, and Prospects." Attending the meeting were Profs. Paul Miceli and Taub from our department,

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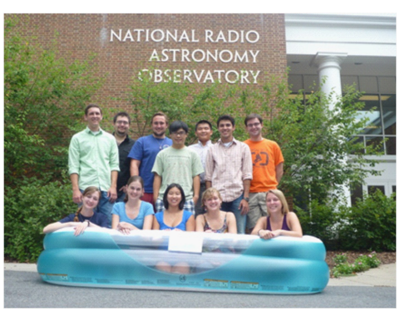
RESEARCH EXPERIENCES for UNDERGRADUATES (REU)

REU with the National Radio Astronomy Observatory (NRAO)

by *Corrine Fletcher,*
Undergraduate Physics Major, UMC

This past summer I had a Research Experience for Undergraduates (REU) with the National Radio Astronomy Observatory (NRAO) in Charlottesville, Virginia. My advisor was Violette Impellizzeri, a post doctoral fellow. I spent the summer using Extended Very Large Array EVLA data to con irm a detection of a 6.7 GHz methanol maser in the galaxy Markarian 3. Over 800 6.7 GHz methanol masers have been found in our own galaxy and three have been found in the Large Magellanic Cloud. They are the strongest masers found in our galaxy and are found spatially near H2O and OH masers. Several surveys have been conducted to look for these methanol masers extragalactically. The surveys focused on galaxies with H2O and OH masers and with similar conditions to the methanol maser environments in the Milky Way. However none of these surveys were successful. In a previous post doctoral fellowship, my advisor used the E elsburg telescope in Germany to conduct a survey for the 6.7 GHz methanol masers looking at completely di erent conditions She surveyed ten galaxies that are all active galactic nuclei. This survey produced a detection of a 6.7 GHz methanol maser in absorption in NGC 3079 and a tentative detection in emission in Markarian 3. Markarian 3 was then observed with the EVLA to con irm the detection Using this data I lagged data and antennas, and did bandpass, amplitude and self calibration with a data reduction program called AIPS. I then created a cube and cleaned while imaging the data. Taking spectra of the data from different areas of the image allowed me to look for where the methanol maser was the strongest. The spectral line was found but still had a lot of noise. The signal to noise ratio gives the line a sigma of approximately 4 which means it is still a tentative detection. Since the spectral line was found at the same frequency as it was in the E elsburg observation and the luminosities were similar the tentative detection is promising. However more observations and better resolution are needed to con irm the detection in the future. If the spectral line is con irmed the methanol maser would be the brightest maser detected and could create a different class of methanol masers. It could also show a di erent way for the masers to be pumped, possibly by the active galactic nuclei itself.



While at the REU I was also able to do some traveling. I attended the 12th Synthesis Imaging Workshop in Socorro, New Mexico, where I learned about interferometry, data reduction, imaging and much more. It was a wonderful networking opportunity and had many social events such as hiking, a pool party and barbeque, and several dinner parties. We went on a tour of the EVLA and were able to walk on one of the antennas. I spent a weekend in Green Bank, West Virginia, where we used the Green Bank Telescope to do a few observing projects. This was another great learning and networking opportunity. I also did lots of sightseeing while in Virginia. The students I worked with were great people that helped me enjoy my REU and my summer to its fullest.

In fall 2010, with the support of the department and graduate school, PAGSA organized a campus-wide career development workshop. The speaker was Dr. Peter Fiske, a nationally known science career speaker.

RESEARCH EXPERIENCES for UNDERGRADUATES (REU)

Quantum Information Science for Undergraduates (QuISU) Program at MIT

by *Lorien Hayden*
Undergraduate Physics Major, UMC

This summer, I had the opportunity to attend the Quantum Information Science for Undergraduates (QuISU) Program at MIT and the NSF funded Research Experience for Undergraduates Program at UCLA. While participating in the QuISU Program, I met many inspiring MIT faculty who have devoted themselves to pursuing advances in the ield of Quantum Information and Quantum Computing including Je rey H Shapiro Seth Loyd, Isaac Chuang and Scott Aaronson. I toured a number of labs and attended lectures on more aspects of quantum computing than I had ever even considered. Not only did I learn about the history of the ield I was introduced to the cutting edge work in the creation of quantum algorithms how di erent types of quantum computing devices work and how they are constructed. I also learned about the planning that goes into making improvements to known systems for performing quantum computation and to developing completely new types of computers.

Following this, I attended the REU Program at UCLA. During my stay, I participated in a research project entitled Quantum Magnetopolaritons under the direction of Dr. Alexey Kovalev. This project was in the ield of theoretical condensed matter and involved studying the e ect of coupling an added degree of mechanical freedom to the macrospin of a single molecule magnet. Speci ically we were interested in the a ect of this coupling on magneto polariton formation and the tunnel splitting in these molecules. The idea was that, if you could signi icantly a ect the molecule's tunnel splitting by rotation or torsional oscillation, this would allow you to e ectively rewrite the spin information of the molecule enabling their application in computer memory systems.

My experience at the UCLA REU was fantastic! I was able to participate in research in my ield of interest and to better prepare myself for graduate study. In addition, I met many wonderful and helpful faculty, sta and students Being around a group of such highly motivated and curious REU students from across the nation was very inspiring. Even though we all had di erent interest the general passion for physics and research was contagious. During my stay at UCLA, I also had the opportunity to attend a Physics GRE workshop, machine shop classes, faculty seminars, ethics workshops and a graduate admissions seminar (hosted by the consultant for the Big Bang Theory!). There was also an optional three day camping trip to Sequoia National Park where I hiked Alta Peak and got to see some of the largest trees on the planet.

My experiences at the QuISU Program and UCLA REU Program this summer have greatly a ected me both personally and professionally. I have met wonderful and inspiring people and have developed myself both as a student and a researcher. I remember at MIT, I was talking with Dr. Shapiro and he said something that will always stick with me. Though I do not remember the exact words the e ect was that to be on the frontier of physics, you have to have a ire in your belly a yearning and passion for your research so great that it is all consuming. Though I'm not sure yet exactly what it is I know I will ind what that thing is for me. This summer has helped immensely to guide me on that path and I am ecstatic to see what the next bend in the road will bring.

Read more about the research and interests of our undergraduate physics majors on our website at:
www.physics.missouri.edu

Physics and Astronomy Graduate Student Association, PAGSA

by *Keshab Paudel*
Graduate Student, UMC

The Physics and Astronomy Graduate Student Association (PAGSA) is a long standing student run organization dedicated to assisting graduate students in their academic careers. The purpose of PAGSA, as stated in its constitution is to:

1. represent physics and astronomy (P&A) graduate student interests to the physics and astronomy graduate faculty and administration through departmental exchange and through projects and programs designed to facilitate research and learning on the part of graduate students.

2. have a forum in which P&A graduate students can voice their concerns affecting their graduate life.

3. enhance the academic pursuits of P&A graduate students by supporting and promoting social and cultural events of interest to graduate students.

4. support special projects and programs involving P&A graduate and undergraduate students.

Fall 2010 new graduate students

Formally all graduate students of physics or astronomy are members of PAGSA. The executives consist of President Keshab Paudel, Vice President Matt Connolly, Secretary Arielle Newgard and Treasurer Jagath Gunasekera. The organization consists of many subcommittees which strive to fulfill the purposes laid out in its constitution by planning social events, representing PAGSA in course planning and providing support for teaching assistants.

In fall 2010, with the support of the department and graduate school, PAGSA organized a campus-wide career development workshop. The speaker was Dr. Peter Fiske, a nationally known science career speaker. PAGSA also hosts custom career seminars every semester on titles such as "How to make effective power point presentation" and "Basics of grant writing" in the Friday noon meetings. One of the highlights of PAGSA's efforts this year is the first graduate student orientation held in the first week of classes. This orientation succeeded in welcoming new graduate students with presentations from PAGSA leaders, Physics faculty and tours of the building, including various labs. One staple of PAGSA is its Journal Club, which is held about three times per month throughout the semester. Journal Club is an opportunity for graduate students to practice public speaking by discussing in depth a journal article. The members of PAGSA and faculty are invited to give advice to the speakers on ways to improve their presentation skills. This semester has already been a resounding success with nearly 20 graduate students signed up to give presentations. PAGSA's social events committee is also planning events throughout this semester to allow students to learn about the diverse cultures represented in our department. PAGSA will continue its efforts throughout this semester and in years to come.

Physics graduate and undergraduate students participated in the Fall Welcome event sponsored by the College of Arts and Sciences. They shared their love of physics with students who stopped at their table to check out the demos they had on display.

Faculty, Students, and Alumni Kudos

Congratulations to

Xiaoqin Zou, on her NSF CAREER Award, "Computational approach to template-based structure selection for protein-protein interaction" ($0.7M)

Ioan Kosztin and **Gabor Forgacs** on their NSF grant entitled "Biomechanics Across Scales: A Combined Computational-Theoretical-Experimental Approach" ($420K) .

Angela Speck, on her NSF award on "Collaborative Research: A laboratory experimental study of astronomical dust analogs at ultraviolet-visible wavelengths" ($40K)

Sam Werner, Professor Emeritus, on his review paper "Observation of Aharonov-Bohm effects by neutron interferometry" (J. Phys. A: Math. Theor. 43, 354006, 2010).

Silvia Bompadre, on her appointment as Assistant Professor (July).

Debi Hanuscin, on her promotion to Associate Professor and Award of Tenure.

Sergei Kopeikin, on his promotion to Professor.

Henry White, Professor Emeritus, on the breakthrough in green LED output power, achieved with the zinc oxide technology developed by MOXtronics, Inc. (June). Henry is in the process of moving his company to Simi Valley, CA.

Ioan Kosztin, on his award of the 2010 P.-G. de Gennes Prize, "for his remarkable contributions to our understanding of condensed matter and biophysics and multiscale modeling of molecular transport in channel proteins and artificial nanopores".

Gabor Forgacs, on having been named as one of FastCompany's 100 Most Creative People in Business 2010.

Matt Mower and **Menzi McHunu**, Graduate Students, on their Harry E. Hammond Award for Excellence in Undergraduate Teaching.

Ping Yu, on his Mizzou Advantage Award, "Early breast cancer detection using novel optical imaging techniques" ($50K).

Sashi Satpathy, on his meeting with Senator Bond and other Missouri Congressmen, during the 2010 Congressional Visit Day organized by the American Institute of Physics to solicit the Congressmen's support for research in the Basic Sciences.

Carlos Wexler, on his article "Hybrid solar panel (photovoltaic and thermal)" having been featured as the most popular article on the website "Instructables".

Tyeece Little, Manager, Grants and Contracts, A&S Grants Center, on her Chancellor's Outstanding Staff Award (May).

Kattesh Katti, on the publication of

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faculty members from Indiana University, neutron scattering leaders at ORNL and NIST, and program officers at the NSF and the Department of Energy.

The purpose of the meeting was to present the case that recent and on-going national investments in neutron sources provide an exciting opportunity for increasing the impact of NSF-funded research and education at U.S. universities. To exploit these opportunities requires systematic efforts to increase the quality and number of graduate students trained in neutron scattering—both as users of these facilities capable of designing experiments to answer increasingly sophisticated scientific questions and as experts in the techniques.

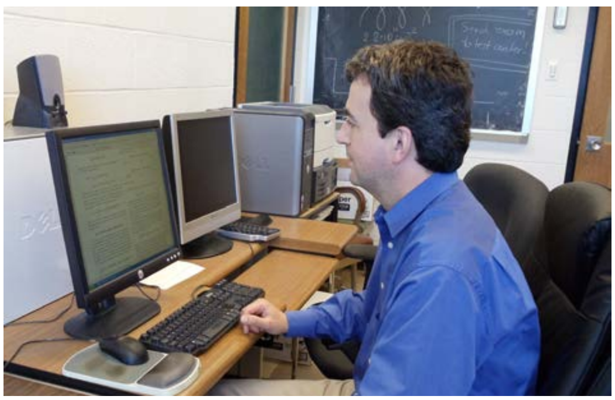
The meeting provided a forum to showcase MU's unique facilities at its research reactor facility (MURR) for training graduate students in neutron scattering techniques. We were able to make the case effectively that not only do we have a variety of neutron scattering instruments available for large blocks of time, but also we have faculty members experienced in both neutron scattering research and training techniques. We also have a track record of placing our Ph.D. students and postdocs in research positions at national laboratories as well as in industry and academic institutions. The NSF Program Officers made a number of helpful suggestions on how we might pursue funding sources at the NSF to support training opportunities in neutron scattering at MU.

Fundamental Electronic Processes in Solar Energy Conversion and in Spintronics

by *Laura Lindsey*,
Director of Communications and Marketing
College of Arts and Sciences, UMC

Absorption of light in solar cell materials

Carsten Ullrich, associate professor in the Department of Physics & Astronomy, is a theoretical physicist whose area of research is theoretical and computational condensed-matter physics. One of the goals of Ullrich's research is to understand the fundamental processes of how light is absorbed in materials so he can find new materials from which to build new kinds of solar cells. His funding from the National Science Foundation (NSF) recently was renewed for this research.



Today, solar cells in calculators and solar panels on roofs come from traditional semiconductors mainly made of silicon. These materials are brittle, expensive, and inflexible. Ullrich hopes that his research will help discover new materials to build improved solar cells that will be lighter, cheaper, and more flexible. If found, these materials will create new possibilities for electronics.

Ullrich studies the processes on a fundamental level and looks to answer what happens when light comes in and reacts with different organic materials and polymers. As a theorist, he gives support to experimental physicists, helps them understand his findings, and gives them new ways to conduct experiments.

He uses the law of quantum physics — using a method called time-dependent density-functional theory — to observe the optical processes in organic and inorganic semiconductors in real time. To do this, he creates specific computer codes to describe the processes, which happen on ultrafast time scales measured in femtoseconds. One femtosecond is a unit of time equal to 10-15 of a second, or one quadrillionth of a second.

Ullrich's goal is to produce movies so he can see how the polymer gets optically excited and to see how this excitation spreads out over the molecule and gets converted to separate charges that will generate electricity.

The findings of this research have built up steadily, and he has now assembled the basic methodologies and new extensive computer simulations. He will further his findings with the additional funding from NSF.

Magnetic Semiconductors

Ullrich's second project, which is funded by the Department of Energy, studies magnetic impurities in traditional semiconductor materials. This type of research, called spintronics, has been happening in the last decade and is meant to combine traditional semiconductors with properties of magnetic materials.

Today's electronics devices are powered by electrons that make currents. However, the electrons also possess a property called the "spin." For traditional electronics, the spin does not matter. But in spintronics, one is looking for new ways of exploiting and controlling the spin, so that new applications for smaller devices that consume very little power can be discovered. The obstacles Ullrich faces are how to add the magnetic atoms to the materials without creating too much disorder and, yet, still control the spin. Ullrich explains that the semiconductor crystal is nice, clean, and ordered, but when he adds magnetic atoms to it that don't belong, it creates disorder and the regular systems don't apply any longer. He is developing methodologies using quantum mechanics to describe the effect the disorder has on the resistance. Ullrich's goal is make a contribution to the field of spintronics.

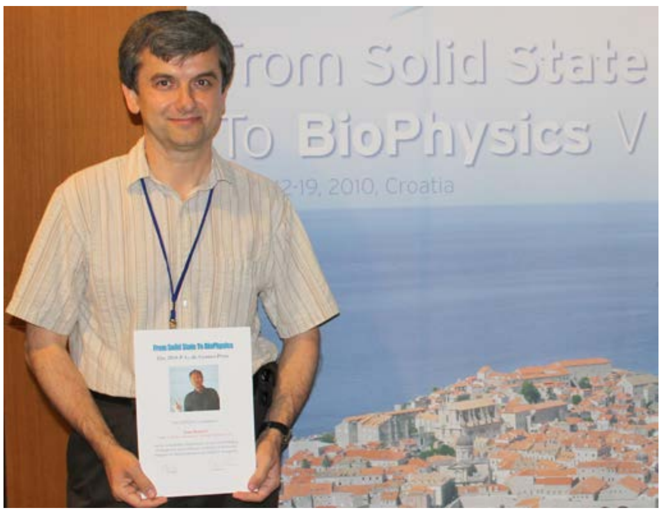
In addition to his research, Ullrich serves as the department's director of graduate studies, where he is responsible for new graduate student recruitment and supervision of master's and doctoral students. Ullrich also enjoys the classroom, and this semester he is teaching introductory physics.

Check out a video of Prof. **Angela Speck** getting dunked during the Fall Welcome on our website at: www.physics.missouri.edu

The 2010 Pierre-Gilles de Gennes Prize awarded to Ioan Kosztin

by *Laura Lindsey*,
Director of Communications and Marketing
College of Arts and Sciences, UMC

Ioan Kosztin, associate professor of physics, was awarded the 2010 Pierre-Gilles de Gennes Prize at the biennial "From Solid State to Biophysics" conference in Croatia on June 15. Kosztin received the award for his "remarkable contributions to our understanding of condensed matter and biophysics and multiscale modeling of molecular transport in channel proteins and artificial nanopores. "The prize is named after the 1991 Nobel Prize in physics winner, Pierre-Gilles de Gennes, who began his career in hard and then soft condensed matter physics before shifting his interest to biophysics and neuroscience.



This prize is intended to encourage young scientists to follow in de Gennes' steps: beginning their careers in condensed matter and subsequently shifting to pursue research in the up-and-coming world of biophysics while also demonstrating promise and leadership potential.

"Man-created artificial boundaries between the physical and life sciences have started to fall," says Kosztin. "It started decades ago, but is happening rapidly now." He moved from condensed matter physics research to biophysics, where he applies quantitative methods used in the physical sciences to solve hard-to-quantify problems in the life sciences.

"I enjoy this field because I want to understand what is going on and how living matter works," says Kosztin. "I have a scientific curiosity, which is why I got into physics and biophysics in the first place."

Recipients for the prize are nominated by an international board of physicists — six of whom are Nobel Prize winners. Kosztin shares this prize with Todd Squires, associate professor at the University of California, Santa Barbara.

"Winning this award is such an honor because my work is recognized by respected names in the field," says Kosztin. "Recognition at an international conference helps to promote our biophysics program at MU."

Attending conferences is a great experience Kosztin says. He was able to attend sessions where he heard other scientists talk about their research, and it was an occasion for him to make professional connections. He is thankful to the MU Research Council for a Faculty International Travel Fund Award that supported his participation in this conference.

"These opportunities allow me to meet researchers with similar interests, but different backgrounds, and we both benefit from our interaction," says Kosztin.

Kosztin received a certificate and a cash prize for this award. In addition, the family of de Gennes requested a picture of the recipients that will be hung in their home. Kosztin predicts the prize will take off in future years as the field expands, and he is humbled to be one of the first to receive the prize established in the memory of the legendary physicist.

Congratulations to **Silvia Bompadre** on her appointment as Assistant Professor of Physics, in the Department of Physics and Astronomy, at University of Missouri Columbia. Read more about her research at: http://dalton.missouri.edu/investigators/bompadres.php

STUDYING ABROAD

by *Nick Kullman*
Undergraduate Physics Major, UMC

Studying abroad is always regarded as fun - di er ent,' 'exciting,' etc. so going in, I was expecting all of these di erent feelings I just didn t know how they would present themselves. I have since found that they hit you full force (but somehow discretely) every day. In your attempt to simply make it through the day, you're confronted with new problems and challenges you never would have thought twice about in your home country. But for my experience personally, I chose to go to Barcelona, Spain because: 1) it had the big city feel I was looking for, 2) it was a good jumping point to other countries for travel throughout the semester, and 3) I could also already speak a decent amount of Spanish.

Regarding my irst point it certainly ful illed the big city wish. Walking to school in the mornings and restaurants/bars in the evenings, the city always had another face to show. From a woman walking four identical pugs on a single hot pink leash, to distinct and varying neighborhoods as you move around the city, to churches that put any here to shame, to pickpocketers asking for directions or to take them to my ATM, to some of the most expensive baby strollers I have ever seen, to skateboarders oblivious to other pedestrians and anti-marijuana laws, every trip was an adventure in its own right. Coming from suburbia, USA, the city life (especially European city life) de initely opened my eyes to how much more ef icient land space can be used and how much more ef iciently we can all get around. Things like free bikes for all citizens and cheap and convenient subway systems make life much greener and much more personable. In the city, the standard form of transportation always forced you to communicate with others, be it your neighbors or just someone on the street, and I feel that this is de initely something we miss with our automobile commutes. I could rant forever on (in my opinion) the superiority of the European lifestyle to our own here, but suf ice it to say that I ve been converted

Using Barcelona as a longer-distance transportation hub also worked out very well—I was able to travel more weekends than not and ended up seeing a decent number of Central European cities. Unlike most other students in the program, despite having some money to travel, I was still living on a pretty tight budget, and as such, I mastered budget living in seven different countries. In Paris, for instance, most desserts have enough calories to essentially take the place of an entire meal and are much cheaper! Problem solved. Also, fresh bread, spreadable cheese, and either salami or chorizo (depending on your location) are all practically free and you can get enough to last you days at a time. Finally, anytime you can get a bottle of "champagne for I highly recommend it For basically the same price, it tastes much better than water.

Not all of my travels were spent scrounging and penny pinching though (just meal times). During the day, there was plenty of sightseeing and learning to do, whether it was about the history of the country, how to speak and read enough to get around, or where not to go. In France, we took a little detour to make our way past the University of Paris' Physics & Astronomy building and the laboratory of Madame Curie. And the highlight of my semester—half a week living with a Swiss-American family at the base of the Alps in Bex, Switzerland. Four of the best days I can remember, we started o thinking the weather was going to ruin the entire span, but we ended up skiing the Swiss Alps, taking curling lessons ('the thing with the brooms'), making cheese fondue, taking a trip to a spa that was fed directly from hot springs at the base of the Alps, and touring CERN. As a physics student, CERN was the icing on the cake, and although they weren't running the LHC while we were there, I can say that I toured the facility (or at least the control room) less than three days before they took measurements for what were supposedly the most energetic collisions ever recorded on Earth. Before leaving I was able to have a picture taken in front of their visitors' center (see the picture above).

All in all, studying abroad was easily the most memorable experience of my undergraduate career. It taught me new meanings of patience, perseverance, and a stronger dedication to detail in everyday life; it exposed me to new scenarios and situations that required a di erent skill set to solve than what I was used to, and it demanded the most out of me and thus returned the most in return (almost just sounds like another semester of physics). Most importantly though, I've learned how to do a rough conversion between Fahrenheit and Celsius in my head, I've learned that drivers are more and more frightening the more countries you visit, that dinner time should actually be at 9:30 PM, and that at Burger King at 10:30 AM, draft beer is the most popular choice of drink with your value meal.

LEADERS MEETING PRESENTATIONS

UNDERGRADUATE STUDENTS PRESENTATIONS

1:30 – 1:45 PM
Corinne Fletcher "*The Search for the 6.7GHz Methanol Maser in Markarian 3*"

ABSTRACT: 6.7 GHz methanol masers are among the strongest galactic masers known, and uniquely trace sites of high-mass star formation. Over 800 of these masers have been detected and studied in our galaxy and three in the Large Magellanic Cloud. These masers are observed spatially near OH and H20 masers. The large number of galactic masers and the existence of luminous extragalactic H2O and OH megamasers has given the motivation to search for 6.7GHz maser emission in extragalactic sources. Several surveys have been conducted to find extragalactic methanol, using H2O and OH megamaser emission as selection criteria. However, none of the surveys have been successful. In 2008, we conducted a survey with the 100m Effelsberg telescope in Germany to observe a sample of AGN selected for being Compton thick and for having a previous detection of molecular lines. This survey produced a detection of the 6.7GHz transition in absorption towards NGC 3079 and a tentative detection towards Markarian 3. Markarian 3 was observed again in 2009 with the EVLA to independently confirm this tentative detection. We report here the detection of an emission line feature at the systemic velocity of the galaxy at 0.56 mJy. With a line peak of 2.12 mJy the emission matches the line observed with Effelsberg. However, due to the low SNR of our detection, the detection remains tentative. If real, the line would correspond to an intrinsic maser luminosity of 1.9 L which would be the most luminous methanol maser found. This would open up the exciting possibility of a new class of methanol masers, possibly associated with AGN activity.

1:45 – 2:00 PM
Lorien Hayden "*Suppression of Macrospin Tunneling by Nanomechanical Interference*"

ABSTRACT: This research considers the quantum dynamics of a nanomechanical resonator coupled to a macrospin of a magnetic nanoparticle. Suppression of macrospin tunneling by nanomechanical interference is demonstrated. By approximating the macrospin molecule as a two level system, the results are extended to the magnetopolariton splitting between resonantly coupled Fock states in which are observed similar interference patterns. The mentioned interference effects should be observable in a single molecule magnet bridged between two leads.

2:00 – 2:15 PM
Matthew McCune "*First prediction of the direct effect of a confined atom on photoionization of the confining fullerene*"

ABSTRACT: We predict that the confined atom can qualitatively modify the energetic photoionization of some cage levels, even though these levels are of very dominant fullerene character. The effect imposes strong new oscillations in the cross sections which are forbidden to the ionization of empty fullerenes. Results are presented for the Ar@C60 endofullerene compound.

GRADUATE STUDENTS PRESENTATIONS

2:15 – 2:30 PM
David Stalla "*The effect of KOH:C ratio and activation temperature on hydrogen storage and structure in activated carbons*"

ABSTRACT: The Alliance for Collaborative Research in Alternative Fuel Technology (ALL-CRAFT) studies specially engineered high surface area activated carbons for the optimization of hydrogen storage. These carbons are activated through treatment with KOH, in ratios of 2.5-6KOH:1C, and heated at temperatures between 700C and 1000C. The effects of KOH:C ratio and activation temperature on hydrogen storage are explored using hydrogen and nitrogen sorption, as well as small angle x-ray scattering.

2:30 – 2:45 PM
Keshab Paudel "*Tuning intermolecular interactions in dioctyl substituted polyfluorene via hydrostatic pressure*"

ABSTRACT: Polyfluorenes (PFs) represent a unique class of poly para-phenylene based blue-emitting polymers with intriguing structure-property relationships. Dioctyl-substituted PF (PF8) is characterized by different backbone conformations that depend upon the torsion angle between the monomers. The application of hydrostatic pressure allows tuning of both intermolecular and intramolecular interactions without changing the material's chemical make-up. We present photoluminescence (PL) and Raman scattering study of thin films, as-is bulk, and thermally annealed bulk samples of PF8 under hydrostatic pressures up to 6.5 GPa. The PL energies of the as-is and thermally annealed samples both red-shift, but at very different rates, and the difference between their pressure coefficients elucidates the role of the backbone torsional angle. The faster rate of red-shift in the annealed sample has been attributed to a change in the torsion angle under pressure as the polymer evolves from a non-planar Cα conformer to a planar Cβ conformer. This is further corroborated by density-functional theoretical calculations of a fluorene oligomer, where the energy gap is calculated both as a function of the torsion angle as well as compression. The Raman peaks harden with increasing pressures; the intra-ring C-C stretch frequency at 1600 cm-1 has a pressure coefficient of 7.2 cm-1/GPa and exhibits asymmetric line shapes at higher pressures, characteristic of a strong electron-phonon interaction.

2:45 – 3:00 PM
Tianyu Liu "*Magneto-electric Control of Spin Waves in Ferromagnets*"

ABSTRACT: The dynamics of spin waves is usually manipulated by magnetic field. In this work we study how an electric field affects the propagation and interference of spin waves. Starting from the electronic origins of Heisenberg Hamiltonian, we show that an electric field can be used to control the phase of spin waves in both metallic and insulating ferromagnets via spin-orbit coupling to the mobile electrons which mediate the exchange interaction between neighboring magnetic moments. We refer this new control as magneto-electric control of spin waves. Together with geometric effects the magneto-electric control has been examined in some topological-non-trivial ferromagnets.

3:00 – 3:15 PM
Mohammad Sherafati "*Graphene vs. metals: Interaction between localized magnetic moments*"

ABSTRACT: Graphene, the honeycomb lattice of carbon atoms, is considered a promising material , because of its unique linear energy dispersion, not seen in two-dimensional metals. I will discuss the exchange interaction J between two magnetic impurities in graphene (the RKKY interaction), magnetic ordering and how it falls off with the distance between the impurities. Two main characteristics are inverse-cubic damping due to the energy linearity and commensurate ordering, ferromagnetism on the same sublattices and anti-ferromagnetism on the opposite sublattices, signifying the bipartite nature of graphene.

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page created by Karen King; Sashi Satpathy's meeting with Missouri Congressmen in Washington (p. 2); the visit of a delegation of neutron scatterers under the leadership of Hak Taub to the NSF (p. 5); a broad range of collective outreach efforts; Meera Chandasekhar's first summer academy for Missouri 9th grade science teachers under the 2009-14 NSF program "A TIME for Physics First," Xiaoqin Zou's research group winning 3rd place in the international competition on protein-protein complex structure prediction (p. 5); Ioan Kosztin's award of the 2010 P.-G. de Gennes Prize (p. 11); and graduate student Raina Olsen as Principal Investigator on an inelastic neutron scattering project at Oak Ridge National Laboratory. I hope these appetizers will pique your curiosity to read more about faculty and student achievements in this newsletter and on our webpage.

Welcome, Physics Leaders, to the 2010 Physics Leaders' Meeting, Oct. 8-9. It is a great privilege to have you here and share some our successes with you. It will be an honor to celebrate Linda Godwin's 30-year career as a NASA astronaut and scientist. It will be fun to hear about life as a graduate student in the Department 30 years ago. We will miss Physics Leader Merilan, who passed away on July 10, 2010, at the untimely age of 54. He was completing his 17th year as the Dean of the Division of Science and Social Science at the State University of New York College of Oneonta, and Director of the College Observatory, College Planetarium, and the campus' astrophysics program.

The final version of this newsletter will include a feature article about this year's Leaders Meeting. Stay tuned!

by *Peter Pfeifer*, Chair
Physics and Astronomy

In Memoriam

Sandra K. Abell, 1956 - 2010

Sandra K. Abell, MU Curators Professor of Science Education, died Tuesday, August 24, 2010. 'Sandi,' as folks knew her, served as Director of the MU Science Education Center from 2001 until her death. Under her leadership, the center formed collaborations with over 60 scientists on the MU campus, launched a 'College Science Teaching' course and certificate program for graduate students in the sciences, and hired three new faculty members, jointly-appointed in the sciences, including Deborah Hanuscin, from the Department of Physics and Astronomy. In addition, the MU Office of Science Outreach, which has enhanced efforts of science faculty in creating broader impacts and educational components on external proposals. Sandi's influence extended far beyond the University of Missouri through her involvement in professional organizations such as the Association for Science Teacher Education (ASTE) and National Association for Research on Science Teaching (NARST), for which she served as President 2000-01. She was a renowned researcher and author, both nationally and internationally, and was named a fellow of the American Association for the Advancement of Science (AAAS), the American Educational Research Association (AERA), and the National Science Teachers Association (NSTA). In addition, she had received numerous awards for both her teaching and mentoring of students. Her passing is a tremendous loss to the science education community, but the commitment to science teaching and outreach that she inspired at MU will continue to flourish. It is in this spirit that the Graduate School at the University of Missouri has established the Sandra K. Abell Scholarship to honor her memory. Funding from this scholarship, housed in the Graduate School, will support doctoral students in the sciences who demonstrate commitment to both research and teaching. Contributions to the Sandra K. Abell Scholarship may be mailed to the University of Missouri, c/o Abell Scholarship, 109 Reynolds Alumni Center, Columbia, MO 65211.

Congratulations to Judy and Owen Vajk, on the arrival of their new baby boy, Andrew!!!

Continued from page 16

his paper "Bombesin functionalized gold nanoparticles show in vitro and in vivo cancer receptor specificity" in PNAS 107, 8760 (2010)

Gabor Forgacs, on his interview on NPR's All Things Considered, "On-Demand Body Parts: Inventing The Bio-Printer".

Sashi Satpathy, on his Gold Chalk Award for Excellence in Graduate Teaching (MU Graduate Professional Council).

Mohammad Sherafati and **Suklima Guha Nyogi**, on their First and Second Prize at the 27th Annual Research and Creative Achievements Forum (MU Graduate Professional Council) in the Physical Sciences Category.

Dorina Kosztin, on her A&S Alumni Organization Faculty Incentive Grant, "Technology enhanced physics learning: virtual labs and video problems"

Wouter Montfrooij, on his and his students' paper featured on APS webpage, Physics -- Spotlighting Exceptional Research, "Magnetic excitations in the spinel compound $Li_x[Mn_{1.96}Li_{0.04}]O_4$: How a classical system can mimic quantum critical scaling"

Suklima Guha Nyogi on her John D. Bies International Travel Scholarship from the graduate school that covered the cost of her trip to the conference "Why Galaxies Care about AGB stars II" in Austria.

Owen and **Judy Vajk** on the arrival of their new baby boy, Andrew Vajk.

2010 Undergraduate Scholarships

Paul E. Bayse Scholarship
Hoban Alex
Kullman Nicholas
Hayden Lorien
Miller Lucas
Grice Jared
Wheeler Jordan

C. W. Tompson Scholarship
Diana Bolser
Corinne Fletcher

D. Packwood Scholarship
Scott Mellenbrink

2010 Graduate Scholarships

O. M. Stewart Scholarship
Danish Adil
David Arrant
Gengsheng Chen
Yiyao Chen
Matt Connolly
Jhuma Das
Michael Gramlich
Suklima Guha Nyogi
Linghui Li
Yonghui Li
Shunlin Liang
Liang Liu
Andrew Miskowiec
Arielle Newgard
Raina Olsen
Jimmy Romanos
Ndubuisi Ukah
Raghavendar S. Gari
Zhiyong Shen
Yochoong Soo
David Stalla
Xiaojun Xu
Jiong Zhang

E. Landen Scholarship
Jagat Lamsal
Menzi Mchunu
Yuan Wang

Harry Hammond Scholarship
Dhanashree Moghe

Editorial Office
Department of Physics and Astronomy
223 Physics Building
Columbia, MO 65211
Phone: 573-882-3335
email: umcasphysics@missouri.edu
Web site: www.physics.missouri.edu