College of Arts and Sciences
University at Buffalo The State University of New York

Interactions

The Newsletter of the UB Department of Physics

Volume 3, Issue 1 Spring 2010

Dear alumni/ae and friends,

PHOTO: D. Revere, UB Reporter 11/4/2009

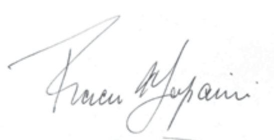
This is the last letter I will be addressing you as Department Chair. I will be stepping down as of August of this year and concentrate again on my research and expanded teaching responsibilities. Before that, I will take a sabbatical during the Fall to focus on new directions. There will be new leadership in the Department starting next Fall with the next generation of faculty stepping up to administrative responsibilities. The Department will be in excellent hands to move beyond our current achievements. In the last six years we have had substantial improvements in total faculty, from 21 to a maximum of 32, with hires in a broad spectrum of research areas. There have been additions in the areas of biophysics, condensed matter, cosmology, and high energy. Our young faculty have been successful in securing funding, and in particular, eight, the latest being Peihong Zhang and Wenjun Zheng, have received NSF CAREER awards. Research expenditures last year were at the highest levels ever. Research productivity is also reflected in the increased number of published articles and citations. The latter exceed 5000 per year. To be sure, there are difficulties and hurdles to overcome. The Department remains seriously understaffed and the faculty count should indeed be even higher to be commensurate with our teaching and research missions. The recent economic downturn has certainly slowed the strong initial momentum of six years ago. But overall, I remain optimistic and prefer a glass-half-full point of view.

An area where new initiatives have been taken during the last six years is in communicating with our graduates and in development. This clearly is important for the Department's future since funding from state sources continues to diminish. Two initiatives, the Ta You Wu Lectureship and the Excellence Endowment have received good support from alumni and friends, but remain shy of their goals of $50,000 and $100,000 respectively. Nevertheless these endowments are beginning to provide a modest income. We are planning to have the first Ta You Wu Lecture this Fall. A new endowment was also created by the Rustgi family to support the Rustgi Professorship, currently held by Athos Petrou. This is the first 'named' professorship in the Department. Lastly, and most recently, Bruce McCombe established an endowment for the benefit of Physics International Graduate Students. I am grateful to all of you who have participated in these initiatives. They will yield continuing benefits in the future and help enhance the stature of your Department.

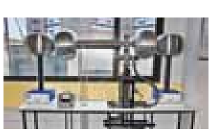
Another area which has had significant impact in our outreach and visibility both on campus and on the wider community is the continuing development of the Physics and Arts Exhibit. This Exhibit, spearheaded by Doreen Wackeroth, will enter a new phase with a substantial expansion and new additions. An inauguration of these new exhibits took place on April 22, 2010. Again, as in the endowments, we have had good alumni and friends' support for this initiative both monetarily and in contributions of displays.

Look inside this issue for information on retirement events for Y. C. Lee and for Shigeji Fujita, highlights of recent publications, for faculty in focus, alumni news and other news. Don't forget, keep in touch and let us know how you are doing.

Best regards,



Francis M. Gasparini, Chair
UB Distinguished Professor of Physics



Banner: A Particle Accelerator, created by Gary Nickard, is among the new additions to the Physics & Arts Exhibition in Fronczak Hall. Read more about the new art installations and the opening reception to celebrate their completion in the Outreach and Events section of this newsletter. Photo: Y. Baur

The Cryogenics Facility

By Dr. John Cerne

An added key advantage for experimental research at UB is provided by the Cryogenics Facility, which is part of the Integrated Nanostructured Systems Instrumentation Facility, and serves several departments, including physics, chemistry, and electrical engineering. Liquid helium (LHe), which has a temperature of 4.2K at ambient pressure, is critical to low temperature experiments, but is not easy to find and is relatively expensive. This is not surprising considering that this element was first observed in solar spectra, hence its name, before it was found on earth! Although the majority of advanced research physics departments around the world recycle their helium by capturing the evaporating gas from LHe and re-liquefying it, most research facilities in the US do not recover their helium gas, which is so light that it floats out to the top of the earth's atmosphere. Although the US has some of the largest helium supplies in the world, LHe in the US currently costs about $10 per liter. When one realizes that many of the cryostats and superconducting magnets in our Department require about 50 liters of LHe for the initial cooldown and consume around 5-20 liters per day, the cost of running these experiments adds up very quickly. Fortunately, by recycling helium our Cryogenics Facility has kept the cost of LHe to about $2 per liter. This provides UB experimentalists with a huge advantage over colleagues in departments without such a facility! The Facility also provides liquid nitrogen (LN) as well as dry nitrogen gas that is piped directly to several first floor labs to purge optical systems and to keep moisture sensitive samples and instruments dry.

The Cryogenics Facility began with helium and nitrogen liquefiers that were installed when Fronczak Hall was built in 1975-76. The original helium liquefier was replaced with a CTI-1410 in the 1994 thanks to a $300,000 NSF infrastructure grant. With a capacity of 25 liters per hour, the new liquefier doubled the liquefaction rate, which is critical since the Facility typically produces 30,000 liters of LHe every year. The NSF grant also allowed the Facility to purchase and install a 12,000 liter LN tank. We typically use 100,000 liters of LN per year.

The Cryogenics Facility is still a work in progress and continues evolving to improve its capabilities. Since the main cost in LHe production is the replacement of helium gas that has not been recovered, we are working to improve our recapture of this gas after it boils off in the labs. We will begin to monitor the amount of gas that is collected in each lab and will use a new billing scheme that rewards labs according to their success in recovering helium gas. We hope that this will improve our helium recovery rate, which is currently about 80%. In the summer of 2007, four huge tanks resembling the space shuttle's solid rocket boosters were added to the Facility. These tanks more than double our capacity to store helium gas, which in turn greatly increases the amount of LHe that can be produced. The molecular beam epitaxy lab typically uses several thousand liters of LN per month, which had to be hauled from the large LN tank to the lab in smaller tanks, so the recent completion of an insulated line that pipes the LN from the large LN tank directly to the lab has been a welcome addition.

Although we are very fortunate to have the valuable hardware that makes up the Facility, the key to its success is the dedication of Jim Wolf, who has operated and maintained the equipment since 1989. Thanks to Jim's regular maintenance and at times emergency repairs, the helium liquefier has run for close to 31,000 hours. The CAS Instrument Machine Shop has worked with Jim not only in keeping the hardware running, but also in expanding and improving the reach of the Facility. Every lab in the Department that needs LHe is now equipped to recover the helium gas, which is sent back to the liquefier through a network of PVC pipes that extends throughout Fronczak Hall. During high demand periods, such as in the weeks before the APS March meeting when many of us are scrambling to collect last minute data, the liquefier often runs nearly continuously, day and night under Jim's close supervision, to provide us with LHe. Jim's commitment to the Facility is critical to the success of many research programs at UB.

Former Cryogenics Facility director Dr. Frank Gasparini (left) with current director Dr. John Cerne in front of the helium liquefier. The olive-drab boxlike instrument on the right cools and compresses helium gas into liquid, which is then collected in the 500 liter dewar in the center of the photo. Photo: J. Wolf

Banner: Liquid nitrogen added drama to the exciting Moti Lal Rustgi Memorial lecture given by Dr. William D. Philips (shown here when he was about to dip a flower in liquid nitrogen). Dr. Philips was awarded the Nobel Prize for Physics in 1997 for developing methods to cool and trap atoms with laser light.

Support Facilities, CONTINUED

The CAS Instrument Machine Shop

By Dr. Sambandamurthy Ganapathy

Some of the unsung heroes behind our department's research and educational activity are the team of support staff that we find on the other side of the Fronczak walk way. Thomas Gruenauer, Kevin Cullinan and Gary Nottingham, with more than 40 years of combined technical service at UB, are the full-time staffers at the CAS Instrument Machine Shop who have transformed many, sometimes crazy, ideas into realistic parts and devices that are important for the day-to-day operations of any lab.

The CAS Instrument Machine Shop staff (left to right): Thomas Gruenauer, Gary Nottingham and Kevin Cullinan. For more information about the shop visit www.casims.buffalo.edu. Photo: P. Wallace

Being the only instrument machine shop for all the departments under the College of Arts and Sciences (CAS), the shop receives more than 100 work orders a year, some small and some large and time consuming. Anybody who has interacted with the machine shop experts can vouch for the enthusiasm and involvement shown in getting a work order completed. The daily work schedule of the experts does not stop at the lathes and drilling machines, but include design consultancy, student training, supporting lecture demonstration set ups, outreach activities and much more. Many of the newer faculty members also remember the help and support received during the daunting task of setting up a new laboratory.

A mere walk through the corridors of the Fronczak Hall and you will not miss the countless displays, demonstrations where the design and implementation of the machine shop were vital. In addition to their regular duties, the shop experts also offer a short course annually to graduate students, and our students benefit immensely from the training provided at the student shop adjacent to the main shop.

The success and recognition that our research and educational activities receive world-wide is built upon hard work and support from several sources and the CAS instrument machine shop has an undeniable role in it.

The Center for Computational Research

By Dr. Peihong Zhang

The Center for Computational Research (CCR) at UB, established in 1998, is one of the most powerful university based supercomputing sites in the U.S. The CCR maintains a high performance computing environment and excellent support staff. The Center's extensive computing facilities are housed in a new state-of-the-art 4000 sq ft machine room with a total computing capacity of about 20 Teraflops.

Photo: Courtesy CCR

During the last 12 months, the CCR delivered 185,000 Cpu-Days to serve the Physics Department's growing activities in theoretical and computational research. The excellent support from the CCR is not only of critical importance to the success of our research program but also provides an invaluable platform for our education and outreach activities. Several of our recent research and educational grants involve the support from the CCR.

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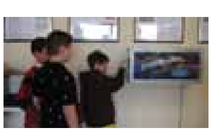
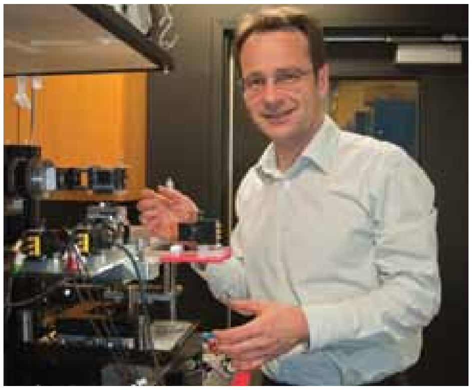


Banner: The Physics & Arts Exhibition in Fronczak Hall features a number of interactive displays built by Thomas Gruenauer and Kevin Cullinan. These displays provide a wonderful opportunity to involve children of all ages during guided tours at occasions such as UB's Bring your daughters and sons to work day. At this event over 20 participants came to see the exhibit. They have been guided through the exhibit in small groups by Dr. Markelz, Dr. Wackeroth and graduate students Catherine Bernaciak, George Lindberg and Joseph Murphy. Photo: D.Wackeroth

Cell Membrane Biophysics – Cholesterol and why we get fever



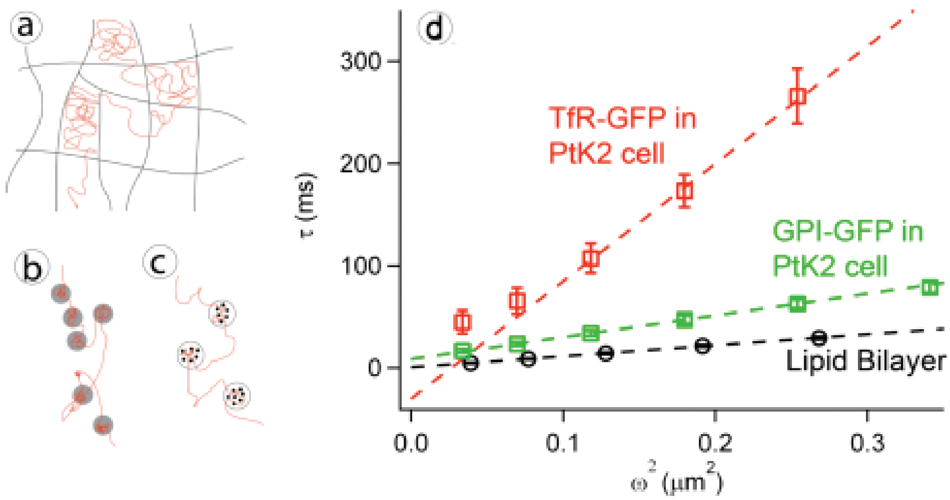
By Dr. Arnd Pralle

What are the benefits of a fever response to an infection? How are proteins and cells optimized to work at 37°C? These are some of the question to which my group seeks physical answers.

At normal temperatures, the water molecules surrounding the proteins in our cells bounce around randomly. The proteins are so small that the random collisions with water molecules cause them to thermally vibrate, tumble and diffuse. Nature has evolved ways to keep proteins together which need to interact, and also to maintain a protein's proper shape while still allowing fast change and even harnessing some of the thermal vibrations. In our research, we develop and apply advanced optical methods using nano-particle tracers and fluorescent probes to study these thermal vibrations. To achieve such resolution, we have built special instruments in a quiet, isolated corner on the groundfloor of Fronczak Hall. Based on the data collected, my group develops models and computer simulations of the structures organizing the proteins.

To understand the benefits of fever, we focus on structure of the cell membrane, which can be thought of as the outer skin of the cell. The cell membrane consists of a thin bilayer of lipids with embedded proteins. Originally, it was thought that the lipids form an oil film like layer in which the proteins diffuse freely. Today, we know that certain lipids prefer to associate with each other, creating a dynamic order, which in turn regulates protein-protein interactions. Some lipids appear to form temporary islands, termed lipid rafts, which are stabilized by cholesterol - an essential component of the cell membrane. The lipid rafts form a second phase inside the liquid-lipid phase, similar to ice-cubes in water. However, the molecules inside the rafts are not frozen like ice, but mobile and form a second liquid phase. In a collaboration with researchers from the Roswell Park Cancer Institute (RPCI) in Buffalo, we have observed that a moderate fever leads to a drastic enhancement of the sensitivity of immune cells. Our measurements indicate that this is caused by a 'melting' of the lipid rafts at the slightly increased fever temperature of 39.5ºC.

My research group currently consists of four physics graduate students who have developed the instrumentation and analysis software. For the biology, they are assisted by a molecular biology technician and undergraduate students with diverse majors including pre-medicine, bio-engineering, and physics. The biophysics research community of Buffalo is spread over the three campuses: the Biophysics and Physiology Department of the Medical School at South campus, a few groups in our Physics Department and in the School of Engineering at North campus, and researchers at RPCI and the Hauptman-Woodward Medical Research Institute at the Medical campus in downtown Buffalo. To make this spread expertise accessible to students and to create synergies, we have organized monthly biophysics research evenings at which groups from the various institutes meet and talk science. Last summer, I organized a Biophysics Bootcamp immersing students into biophysics theory and laboratory techniques all day long for 10 days: each morning began with 3 hours of lecture followed by a day of experimental work.



Influence of the possible cell membrane structure on the protein diffusion. The protein diffusion can be confined and reduced by transient trapping (a) between cytoskeleton elements, (b) in lipid domains, or (c) in protein domains. (d) Experimental data for free diffusion (Lipid Bilayer), trapping between cytoskeleton elements (TfR-GFP) and trapping in lipid domains (GPI-GFP).

Banner: The sound art installation *Music of the Spheres* by artist Gary Nickard was heard first at the opening reception for the new addition to the permanent Physics & Arts Exhibition in Fronczak Hall. Photo: Y. Baur

Some Aspects In Condensed Matter Physics

By Dr. Y. C. Lee

In this article I would like to review a selected few of the topics that are of particular interest to me. For brevity, only three of these topics have actually been chosen. Even then, only the bare essential physics, perhaps aided by a physical picture or two will be given.

(1) The study of the spin-related properties of ultra-thin magnetic films is of scientific and practical interest. Hence, it is important to acquire a thorough understanding of the spin dynamics and magnetic relaxation processes. We extended our earlier studies of superradiative decay of various elementary excitations in confined geometries to the decay of magnetic excitations (magnons) in thin films into elastic waves (phonons) of the surrounding non-magnetic medium. For this purpose we must focus on the interaction between spin waves and the elastic deformation of the crystal lattice. Not to let the nonessential mathematical and physical details cloud the main issue, we adopt a simple generic approach to the magnon-phonon interaction. Although magnon-photon interaction would generally be present, it can be shown that it only yields much weaker decay rates by roughly a factor of c_{light}/c_{sound} and can hence be ignored. The physical reason is that a lattice displacement changes directly the exchange overlap integral between neighboring spins, which basically involves the longitudinal, coulombic interaction. On the other hand, an electromagnetic wave tends to affect the spin via the transverse, magnetic interaction (i.e., with the speed of light c directly involved). This gives rise to the appearance of the factor c_{light}/c_{sound} in the ratio of the decay rates via the two different channels - phonons and photons. As a consequence, the decay rate of a magnon into phonons in the surrounding elastic medium is much greater than that caused by magnon-photon coupling. Analogous to the exciton decay studied previously there is also the anticipated superradiative enhancement caused by the coherence between the magnetization wave field and the elastic wave field in the film. Since the magnon energy, as expected physically, is an important energy scale that appears explicitly in the decay rate, an external applied magnetic field may serve as an experimental knob to tune the magnon energy and hence control its decay rate.

(2) Pursuing the effect of broken symmetry, we now turn to the study of phenomena in some confined systems, specifically possible SAP-mediated High Tc Superconductivity. It is well known that the main ingredient of superconductivity is the Cooper pair, the binding of two electrons of opposite momenta and spins. The strength of the attractive coupling for the binding depends on how effective it is to mediate a force via the exchange of a phonon or other bosons between the two electrons (i.e. emission of a phonon by one electron followed by its absorption by the other electron). Two factors are essential. The first is the magnitude of the matrix element coupling the electron and the phonon, the second is whether the exchange process is far off the energy shell or nearly on the energy shell (i.e., nearly energy-conserving). We recall that the phonon originates from the collective vibrations of atomic ions, which are heavier than an electron by several orders of magnitude. To emit a phonon requires an electron (a tiny mouse) to kick Coulombically a heavy ion (an elephant) into action. This scenario dramatizes the relative feebleness of the electron-phonon coupling on account of the unfavorable mass ratio. In comparison, if the phonon's role could be played by a plasmon consisting of electron oscillations, the elephant-like ions would be out of the picture while the relevant force between an electron and a plasmon remains basically the same – Coulombic type. Hence the unfavorable mass ratio is eliminated. However, with respect to the second factor that arises from the on-shell or off-shell consideration of the virtual boson exchange process we would much prefer the electron to emit a boson of smaller energy so as to minimize the energy violation in the intermediate state.

As we know, the acoustic phonon frequency is linearly proportional to the wave number, approaching zero in the long wavelength limit, independent of dimensionality. On the other hand, we already know that in three dimensions the plasma frequency is a constant independent of the wave number. This makes the idea of exploiting the high-energy plasmon in lieu of the low-energy acoustic phonon as the mediating boson unfavorable. However, in a one-dimensional system the plasmon becomes acoustic-like, rendering it possible to compete on equal footing with the phonon as far as the second factor is concerned. Thus, when both factors are considered, a thin wire with the many branches of what we called slender acoustic plasmon (SAP) should compete favorably to be the mediating boson of the attractive force between the Cooper pair.

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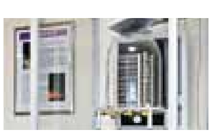
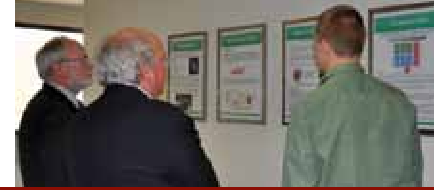


Banner: The Spark Chamber, a (almost) fully functional scientific instrument created by artists Gary Nickard and Reinhard Reitzenstein, is now on display in Fronczak Hall. It uses scintillating material to detect cosmic rays consisting of muons. Work is still needed to see the sparks from the discharge between the metal plates in the helium filled chamber along the path of the muons. PHOTO: Y. Baur



Yongjie Wang, Ph.D. 1993
By Dr. Bruce McCombe

1957-2009

Doctor Yongjie Wang, a scientific staff member at the National High Magnetic Field Laboratory (NHMFL) in Tallahassee, Florida, and a former PhD student in the Department of Physics, passed away from cardiac arrest on December 12, 2009 at the age of 52. He is survived by his wife, Xiaowei Wang, two daughters, Wanda, of Chicago, Illinois, and Stacy, of Tallahassee, Florida, and three brothers, Junjie and Xianjie, of China, and Mengjie, of Columbus, Ohio, as well as three nephews and a niece.

Born on January 16, 1957 in Hefei, China, Yongjie attended Beijing University, graduating in 1982 with a BS in Physics. At UB he was a student of Professor Bruce McCombe's in the Department of Physics, receiving his PhD degree in September, 1993; his dissertation is entitled "Metal-Insulator Transitions in Confined Semiconductor Systems in High Magnetic Fields". After receiving his degree, he joined the NHMFL, where he spent his entire career.

Yongjie was an expert in high field magnetospectroscopy, primarily in the infrared region of the spectrum; he was responsible for the NHMFL Infrared Optics User facility and did his own research in this area, in addition to collaborating with users from around the world. His recent collaborations included research on magneto-elastic interactions in magnetic systems, cyclotron resonance in graphene, and more generally, infrared magnetospectroscopy in heavy fermion systems and semiconductors. He was a visiting professor at the National Laboratory for Infrared Physics of the Shanghai Institute of Technical Physics, in the Chinese Academy of Science. He also recently made significant contributions to the development of the new High Magnetic Field Laboratory of the Chinese Academy of Science in his hometown of Hefei, China. He was chair of the Organizing Committee of the 16th International conference on High Magnetic Fields in Semiconductior Physics, Tallahassee, FL, 2004, and recently had been chosen to be a co-organizer of the 19th Conference on Electronic Properties of Two-dimensional Systems, and the 15th Conference on Modulated Semiconductor Structures, to be held jointly in Tallahassee, FL in the summer of 2011.

Sports and games were always an important part of Yongjie's life. He got to know American Football while at UB and was an avid fan of the FSU Seminoles and the Buffalo Bills. He played tennis, badminton, table tennis, and soccer, all with great enthusiasm.

Yongjie touched many people. He was very outgoing with a ready smile, and clearly enjoyed life. He had a wide circle of friends from his time at UB, in Tallahassee, and throughout the world. All of us will miss him.

Eric Greenwood, Ph.D. 2010
By Dr. Dejan Stojkovic

Eric Greenwood defended his Ph.D. thesis "Quantum Mechanical Effects in Gravitational Collapse" on Jan 5, 2010. When I joined the Department in Fall 2007, Eric expressed his strong interest in working in the field of gravity and cosmology. In just over two years under my supervision, he published 7 papers in leading peer reviewed journals including JHEP, JCAP and PRD. Two of his papers were single author papers, clearly demonstrating his creativity and independence. Eric is currently a postdoc at Case Western Reserve University in Cleveland as a member of their Particle-Astrophysics and Cosmology group.

Edward Kintzel, BS 1998
By Dr. Hong Luo

Professor Edward Kintzel graduated from UB with a BS in Mathematical Physics in 1998. Working with Dr. Luo as an undergraduate student, he showed a great deal of interest in structural studies of various materials and worked on scanning tunneling microscopy. He joined the Physics Department at Florida State University and received his MS (1999) and PhD (2002). The focus of his PhD dissertation was on "Controlled Growth of Ultrathin Molecular Films of the p-Phenylene Oligomer Molecules on Alkali Halide Substrates". After his PhD., he joined Dr. Kenneth Herwig's group and worked at the Spallation Neutron Source (SNS) and Oak Ridge National Laboratory (ORNL). His research focus was the use of elastic and quasielastic neutron scattering to investigate the structure and dynamics within low-coverage (i.e. mono-, bi-, and multi-layer systems) on a variety of high surface area substrates (e.g. GRAFOIL, MCM-41, Carbon Aerogels). He worked briefly at Washington University's Medical School, in the Department of Radiation Oncology as a Research Fellow and Staff Scientist (2007 – 2008). In May 2008, he joined the Physics Department at Western Kentucky University as an assistant professor. His current research interests include the study of molecular dynamics in confinement using neutron scattering at the SNS, adsorption studies of alcohols on carbon aerogels, dynamics of methane adsorbed onto nanoporous carbon, software development for the sample environment group at the SNS for an automated gas environment system (AGES), and other sample environment

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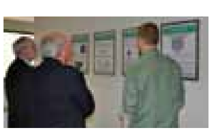

Banner: President John Simpson (left) and Senior Associate Dean Charles Stinger (middle) took the opportunity to tour the Physics & Arts Exhibition during the opening reception (read more in the Events and Outreach section of this newsletter). Ian Moskal (right), a high-school senior and PASI 2009 participant, shows them the wonder room exhibit (see www.physics.buffalo.edu/ubexpo for more information about the exhibit). PHOTO: Y.Baur

Alumni News, CONTINUED

UB Physics at the APS March meeting

By Andreas Stier

It is a tradition that current and past members of UB Physics get together in an informal way on the first Tuesday during the APS March meeting in the respective city where the conference is held. This is a great opportunity for current UB Physics professors to meet with former students, as well as current students to meet previous student generations. This year in Portland, we decided to meet at Deschutes Brewery and Pub to support the fine local hops processing craftsmen and craftswomen. We were able to welcome former UB students currently working in local silicon processing (Intel) industry. Due to our close ties to the Naval Research laboratory, we were also accompanied by a group of physicists from Washington who eagerly tried to replicate our quantitative results on the hops international bitterness units. The event was a great success with almost twice as many people attending (~40) as anticipated. We are looking forward to continue the event next year in Dallas, TX!

J.Kono, Z.Jiang, D.Finotello, J.Tischler, B.McCombe, E.Glaser, R.Bush, M.Furis, B.Bezanson. Photo: C. Ellis

Support the Department of Physics Programs

The Physics department is grateful to all our alumni and friends for their contributions. These contributions provide the margin which makes UB Physics an excellent Department. In today's environment of decreasing government support the contributions to any of these funds are instrumental in the quality of our academic endeavors every year. To contribute electronically, please visit www.physics.buffalo.edu and click the Support Physics button on the top right or contact Chris Gleason in the Physics Department at 716-645-3629 or via e-mail cg57@buffalo.edu. You may also contact Deborah McKinzie in the Development Office at 716-645-0839, or via email at mckinzie@buffalo.edu with any questions.

Physics Department Funds:

Physics Excellence Endowment: Supports recruitment and recognition of outstanding students, outreach to the community, upper level experimental laboratories, undergraduate research projects, and activities of The Society of Physics Students.

Frank B. Silvestro Endowment Fund: Established in 2000 by Mr. Frank Silvestro, BA 1962, MA 1968, the fund supports outstanding students with financial need. Currently used to support graduate students.

Dr. Stanley T. Sekula Memorial Scholarship Fund: Established in 1990 by Mrs. Anne H. Sekula, honoring the memory of Dr. Stanley T. Sekula, BA 1951, and used to recognize outstanding undergraduates with financial need.

Moti Lal Rustgi Professorship in Physics: Endowed by the Rustgi family in 2006 to honor the late Professor Moti Lal Rustgi. Provides support for the Rustgi Professor, currently held by Professor Athos Petrou.

Moti Lal Rustgi Memorial Lectureship Fund: Established in 1993 by the Rustgi family, the fund supports an annual lecture by distinguished researchers.

Ta-You Wu Lectureship Fund: Established in 2008 by Professor Yung-Chang Lee in remembrance of the late Professor Ta-You Wu, who was a key member of the Department from 1966 to 1978.

Physics & Arts Exhibition Fund: This interactive permanent exhibition in Fronczak Hall opened in 2006, and was funded by alumni. It is one of the Department's most effective outreach initiatives. Support will allow continued evolution and development.

Physics International Graduate Student Assistance Fund: Established in 2010 by Professor Bruce D. McCombe to provide support for critical financial assistance to international graduate students in the Department of Physics, with a preference given to Asian students and 1st year Ph.D. candidates, at the University at Buffalo.

Thank you to our donors for their 2009 contribution to the Physics Department funds:

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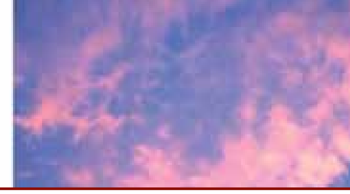
Zhang, Peihong
Zheng, Wenjun
Zutic, Igor

Banner: During his visit at the UB Department of Physics, our undergraduate students had the opportunity to meet with Dr. Phillips, a Nobel Laureate and this year's Moti Lal Rustgi Memorial Lecturer. The annual Moti Lal Rustgi Memorial Lecture is made possible by the generosity of the Rustgi family. Read more about Professor Rustgi and the Rustgi Lecture Series at www.physics.buffalo.edu/talks/Rustgi-Lectures.html.



Research News and Awards

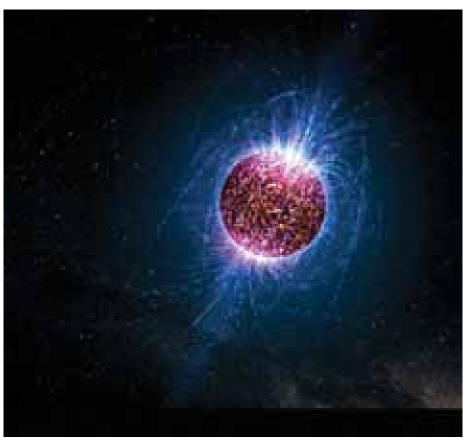
Interactions Volume 3, Issue 1

The Electroweak Stars

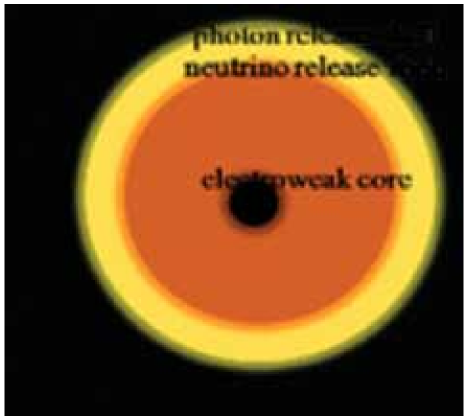
By Dr. Dejan Stojkovic

My research focuses on fundamental, unanswered questions in physics, mostly on the interface of cosmology, gravity and particle physics. Together with my postdoc De Chang Dai, and our colleagues Arthur Lue from MIT and Glenn Starkman from Case Western Reserve University, we proposed the existence of the new class of stars that we named "the electroweak stars" [a research paper entitled "Electroweak stars: how nature may capitalize on the standard model's ultimate fuel' was submitted to PRL].

Stellar evolution from a protostar to neutron star is of one of the best studied subjects in modern astrophysics. Yet there is still a lot to learn about the extreme conditions where fundamental particle physics meets strong gravity regime. After all of the thermonuclear fuel is spent, and after the supernova explosion, but before the remaining mass crosses its own Schwarzschild radius (and becomes a black hole),



the temperature of the central core of the star might become higher than the electroweak symmetry restoration temperature. The source of energy, which can at least temporarily balance gravity, are baryon number violating instanton processes which are basically unsuppressed at temperatures above the electroweak scale. We constructed a solution to the Oppenheimer-Volkoff equation which describes such a star. The energy release rate is enormous at the core, but gravitational redshift and enhanced neutrino interaction cross section at these densities make the energy release rate moderate at the sur-



face of the star. The lifetime of this new quasi-equilibrium can be more than ten million years, which is long enough to represent a new stage in the evolution of a star.

While we found the numerical solution of Einstein's equations that describes these "electroweak stars", it still remains that astrophysical observations confirm their existence.

You can read more about the electroweak stars here:

http://www.astronomy.com/asy/default.aspx?c=a&id=8895

http://physicsworld.com/cws/article/news/41269
http://www.technologyreview.com/blog/arxiv/24505/

http://en.wikipedia.org/wiki/Electroweak_star

http:www.foxnews.com/scitech/2010/01/22/science-adds-new-class-stars-electroweak/

http://today.msnbc.msn.com/id/35019773/ns/technology_and_science-space/

Electronic Structure of Ferromagnetic Semiconductor Ga1-xMnxAs Probed by Subgap Magneto-optical Spectroscopy," G. Acbas, M.H. Kim, M. Cukr, V. Novak, M.A. Scarpulla, O.D. Dubon, T. Jungwirth, J. Sinova, and J. Cerne, Phys. Rev. Lett. 103, 137201 (2009).

Diluted magnetic semiconductors such as Ga$_{1-x}$Mn$_x$As (GMA) are highly interesting both from a basic research perspective (e.g., carrier mediated magnetism and a Hall response in the absence of a magnetic field/Lorentz force) as well from a technological point of view (e.g., electric field control of magnetism, spintronics). Infrared longitudinal conductivity s_{xx} measurements probing the valence band of GMA directly (e.g., Burch PRL 2006) and higher energy interband Faraday/Kerr measurements (e.g., Ando PRL 2008), provided exciting but conflicting results. As a result there have been two competing models used to explain the magnetic and optical properties of GMA. One model suggests that the carriers responsible for transport and magnetism move in a Mn impurity band inside the band gap while the other model assumes that GMA behaves more conventionally, with hole-like carriers moving in the GaAs valence band. Distinguishing between these two pictures is of critical importance in understanding GMA and has motivated our new measurements.

Infrared (IR) s_{xx} measurements probe currents generated along the radiation's excitation electric field and are sensitive to the sum of the sample's response to left and right circularly polarized light (absorption). On the other hand, infrared Hall conductivity s_{xy} measurements probe currents that are generated perpendicular to the radiation's electric field and therefore are sensitive to the difference in the sample's response to left and right circularly polarized light. This allows infrared s_{xy} measurements to resolve chiral asymmetries such as those produced by spin-splitting of electronic levels. We obtain s_{xy} by measuring the polarization change (rotation and ellip-

Banner: Dr. Dejan Stojkovic recently published a book entitled "Massive Neutrinos and Topology of the Standard Model: Cosmic Strings, Domain Walls and Index Theorems", VDM Verlag (Germany), 2009. This book is available through Amazon (www.amazon.de) and Books on Demand (www.bod.com).

Research News and Awards, CONTINUED

polarization change (rotation and ellipticity) of transmitted (Faraday angle, q_F) and reflected (Kerr angle, q_K) light, as functions of magnetic field, frequency, and temperature for a range of

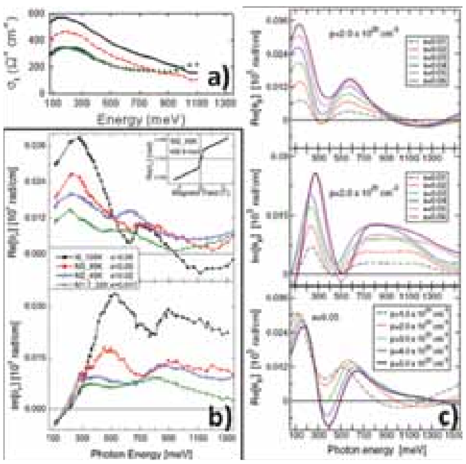


Fig.1: a) s_1(E) for several GMA films adapted from Burch et al., PRL 2006, b) Faraday rotation Re(qF(E)) (top) and ellipticity Im(qF(E)) (bottom) for similar films, and c) calculated values of Re(qF(E)) and Im(qF(E)) for 50nm thick films.

samples with varying Mn concentration (x) and carrier concentration (p). These measurements were pioneered in the Cerne lab at UB by Gheorghe Acbas, who is now a post-doc in J. Levy's group at the University of Pittsburgh.

By probing the valence band directly using IR s_{xy} measurements, we are able to look at the electronic structure of the valence band in greater detail and find that the valence band model can explain the IR Hall response (see Fig. 1c). Unlike IR s_{xx} measurements (see Fig. 1a) that show a single broad (~1eV) feature in Re(s_{xx}) (also called s_1), we observe relatively sharp features and sign changes in s_{xy}, which is closely related to q_F and q_K, as predicted by the theory (see Figs. 1b and c). Note that s_{xx} and s_{xy} are complementary quantities and the features in s_{xy} often cannot be seen in s_{xx}. Furthermore, unlike higher energy Faraday and Kerr measurements, we directly probe the valence band, avoiding complications from the conduction band.

Research Awards

By Dr. Sambandamurthy Ganapathy

Research activities at the department are growing significantly with several of the faculty obtaining new grants for their research from federal funding agencies in the recent months. We report here the latest awards and a short description of the planned research activities.

Dr. P. Zhang and Dr. W. Zheng have recently received the prestigious CAREER grant from the National Science Foundation. Dr. P. Zhang's project is titled "CAREER: Excited States Properties of Semiconductors and Nanostructures: Methodology Developments, Practical Applications, and Education." The goals of the proposed research, educational, and outreach projects are to develop a theoretical framework that enables accurate and efficient calculations of quasiparticle and optical properties of solids and to promote physics education. Dr. W. Zheng's project is titled, "CAREER: Multiscale Structural and Dynamic Modeling of Kinesin-Microtubule Motor System", which will support his research to elucidate how kinesin motor moves along microtubule tracks using computer modeling.

National Science Foundation's Major Research Instrumentation grant was recently awarded to Dr. A. Markelz (Physics), J. Cerne (Physics), K. Oh (EE) and E. H. Snell (Structural Biology) to develop two complimentary instruments: Spectral Terahertz Imaging Microscopy (STIM) and Dynamic Alignment Terahertz Spectroscopy (DATS). This pair of instruments is essential to address a fundamental question: what is the role of collective motions in protein function? Answering this question has an immediate impact on biological physics, and bioengineering.

Dr. P. Zhang recently received a grant from the Department of Energy, Office of Basic Energy Science for a collaborative project entitled "Defect Modeling Beyond Density Functional Theory". Under the support from this grant, the team will develop new theory and methodology for modeling defect properties in solids beyond the traditional density functional theory.

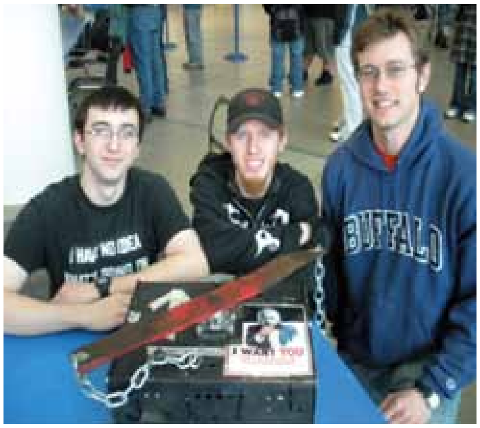
Dr. I. Zutic has received a three-year grant from the US Office of Naval Research for the project Bipolar Spintronics. This is the continuation of his earlier ONR grant which has the goal of exploring potential spin-based applications in solid state systems where both electrons and holes are simultaneously present. He has also received (as a Co-PI) a three-year grant from the Air Force Office of Scientific Research for the project on Controlling Magnetic and Optical Response for Spin-Based Information Transfer, a collaboration with the University of Rochester. The goal of this proposal is to study the feasibility of reconfigurable spin logic and interconnects by elucidating spin-dependent and magnetic properties of semiconductor nanostructures.

Professors Hong Luo, Athos Petrou and Joseph Gardella, Jr (Chemistry) recently received an NSF/DMR grant for three years, starting this summer. The title of the project is "Study of Diffusion of Magnetic Ions in Semiconductor Heterostructures and Its Effects on Spin Injection".

Banner: Heng Huang, a graduate student of the Department of Physics under the advisement of Dr. Arnd Pralle (see article in section Faculty in Focus), received a Tascione Travel Award to attend and present at the 54th Annual Biophysical Society Meeting in San Francisco, February 20-24, 2010.

Society of Physics Students robot fights (and dies) valiantly

By Dr. John Cerne



Undergraduates Daniel Ferris, Jared Parks and Grady Gambrel (left to right) with the SPS robot before the competition.

Months of ingenious design and hard work ended in a flash of steel slamming into the aluminum body of our SPS battle robot. Our SPS robot, piloted by Jared Parks and assisted by Daniel Ferris, faced the IEEE2 robot in the first round of the UB Engineering Week Bot Wars competition in the Student Union on February 19, 2010. The IEEE2 robot had some technical problems in getting started and our team was offered a win by default, but being good sports they decided to give the IEEE2 team more time to fix their robot.

The IEEE2 robot consisted of a low disk-shaped body spinning a large sharpened lawn mower blade at 1500 rpm using a 2000W electric motor! The SPS robot, named Schroedinger's Box by the team, swung two chains at the ends of a lawnmower blade at a similar rate. In fact, although the SPS robot was within the competition specifications, the judges asked the SPS team to remove the three pound steel blocks that were originally attached to the ends of the chains, fearing that we would damage the plexiglass enclosure in which the robots battle! Losing the bludgeoning effect of these blocks and the low height of the IEEE2 robot severely handicapped the SPS robot's punch. When the match resumed, the IEEE2 robot was able to go under the spinning chains of our robot and struck a corner of our robot with its blindingly fast lawnmower blade. At least our robot's death was quick, as the impact broke the rotator motor gear box, knocked off one of the drive wheels, and ejected one of the batteries.

Although the match result was disappointing, the SPS team has many reasons to be proud or their work. This year they tried a totally new weapon design, and the deadly swinging blocks raised many eyebrows of the competitors as well as the judges, who feared for the survival of the arena, not just of other robots. The robot also used a new chassis, made from a discarded microbalance control box. Jared and Daniel led the design and building efforts. The lawnmower blade was powered by a motor taken from a cordless circular saw. Unlike past years, when the SPS robot suffered from electronic reliability problems, this year's robot was very robust, with the drive train and lawnmower blade motor responding perfectly to radio-controlled commands. Much was learned in the design, building, testing, and destruction of our robot and we look forward to using these lessons to build an even better robot next year!

Events Calendar

March 27, 2010
Physics Open House

April 7, 2010, 7 pm
Science & Art Cabaret 'Invisible Worlds' in the Ninth Ward @ Babeville

April 22, 2010, 5 pm, Fronczak Hall
Physics & Arts Exhibit opening reception

April 23, 2010, 5 pm, 225 NSC
Sixteenth annual Moti Lal Rustgi Memorial Lecture given by Dr. William D. Phillips on Time, Einstein and the coolest stuff in the universe.

June 26, 2010
The Ride for Roswell, join the Physics Department team Ubphysics to raise money for the Roswell Park Cancer Institute. See www.physics.buffalo.edu for information about how to participate and donate

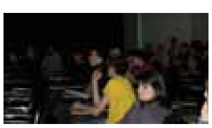
August 2-20, 2010
Physics and Arts Summer Institute for high-school students (PASI 2010), see www.physics.buffalo.edu/pasi for more information

August 18, 2010, 8 pm
Science & Art Cabaret No.2.5 on the roof of the Buffalo Museum of Science

August 28, 2010
Retirement party honoring Dr. Y. C. Lee

October 9, 2010
Retirement party honoring Dr. S. Fujita

October 2010
Physics Open House



Banner: The Physics Department is involved in a wide variety of outreach activities. Shown here are area high school students on Science Exploration Day, attending Dr. Dejan Stojkovic's presentation. Science Exploration Day, held on March 10, 2010 is an opportunity for high school students from the greater Buffalo area to learn from educational presentations and interact with researchers and scientists. Dr. Stojkovic was also invited to present at the Exploration and Development of Space Northwest Conference (SEDS) at UB on March 20th, 2010, a completely student run conference. PHOTO: C. Gleason

Physics & Arts Opening

By Dr. Doreen Wackeroth

Left to right: President John Simpson, Dean Bruce McCombe, Prof. Frank Gasparini and Prof. Doreen Wackeroth enjoying the new installations at the opening reception. PHOTO: Y.Baur

On April 22, we celebrated the new installations of the Physics & Arts Exhibition in Fronczak Hall, which includes a series of unique sculptures and artistic graphics (presented in this and past newsletters) created by Gary Nickard, Reinhard Reitzenstein and Patty Wallace. The realization of these new exhibits was made possible by the Robert and Carol Morris Fund for Artistic Expression and Performing Arts and by the continued support of our alumni and friends. The first part of the exhibit opened in 2006 and since then has become an integral part of the Department and an effective outreach tool.

Prof. Gary Nickard (right) and Senior Associate Dean Charles Stinger (left), who officially opened the exhibit by bringing the Music of the Spheres to life. PHOTO: Y. Baur

Such a long-term commitment is not possible without the enthusiasm and inspiration of the artists and physicists involved and the continued support of the entire physics department, the UB administration and the CAS Instrument machine shop staff. Special thanks go to Kevin Cullinan, Tom Gruenauer, Renee Ruffino (Creative Art Director, Visual Studies) and Chris Gleason, for helping making this event a success. The exhibit is open to the public and guided tours can be arranged by contacting Chris Gleason, cg57@buffalo.edu.

"Condensed Matter Physics"

By Dr. Y. C. Lee

cont. from pg 5

Based on the pairing interaction mediated by the quasi-one dimensional plasmons as well as the multiple branches of the so-called slender acoustic plasmons (SAP) a possible mechanism of superconductivity in slender electronic systems is proposed. Numerical results on Tc in various samples are presented, showing values in the 150-200 K range. The ratio $2\Delta_0$/Tc differs generally from the BCS value due to the temperature dependence of mode damping. The associated coherence length is shown to be considerably smaller than the transverse dimension of the wires. This work is later extended to quasi-one-dimensional multi-wire structures, showing Tc in the 200-K range. This is enhanced over the critical temperature of the single-wire system. This fact stems from the in-phase Coulomb wire-wire coupling. The numerical values are based on wires of cross section 200Åx 100Å. These predictions were first made prior to 1987.

After the discovery of the new crop of high-Tc superconductors in 1987 there have been occasional rumors that some samples of thin wires had been found to exhibit superconductivity with surprisingly high critical temperatures. Although these rumors were communicated to us from reputable laboratories in Texas, none of them have appeared in print.

(3) As the last topic in this article, I would like to discuss indistinguishability and Bose-Einstein Condensation (BEC). The concept of indistinguishability is the key element in quantum statistics. But, are particles really either indistinguishable or distinguishable? Most works begin with the premise that all particles, for example, in a quantum gas, are indistinguishable. Can we tune the degree of distinguishability in some controlled, continuous manner and see how it affects the behavior of the quantum gas, such as BEC? We have found a complex parameter connected with the spin orientations of the bosons with a definite phase that does just that. As it deviates from zero, a gas mixture of originally indistinguishable bosons would divide into several distinct species that would undergo BEC at its own critical temperature individually, at different stages. Each species is in a new and different quantum state whose spin structure adapts itself to the prevailing densities of the gas in the mixture. We emphasize that the tuning parameter is not connected to the degree of spatial overlap of the bosons in the gas and is hence not closely related to the density of the particles. It is also interesting to find a parallel of our special quantum-statistical correlation with the well-known quantum entanglement between particles in quantum mechanics.

"Edward Kintzel"

By Dr. Hong Luo

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projects for the SNS. He is the proud owner of a Large Chamber Scanning Electron Microscope (LC-SEM, shown in the photo), one of ten in the world, donated by the Department of Energy. More importantly, he became a proud papa of a son born on July 1, 2009. Ed visited us many times at various stages of his career. We are very proud of his accomplishments since he left here, starting with the boy, of course!

Banner: A second Science and Art Cabaret, founded and organized by Prof. Will Kinney and sponsored by the University at Buffalo and Hallwalls Contemporary Arts Center, took place on April 7th in the Ninth Ward in Babeville's Asbury Hall. A panel of UB physicists, artists, and a representative from the Buffalo Museum of Science gave their perspective on "Invisible Worlds", supported by David Gutierrez performing on Theremin. Watch for the announcement of the third Science and Cabaret in Summer 2010. More information can be found at www.physics.buffalo.edu/outreach/cabaret.html. PHOTO: A. Pralle (left to right: D. Borzynksi, G. Nickard, D. Wackeroth, W. Kinney)

The University at Buffalo Department of Physics Newsletter

Faculty, staff, and students, along with family and friends are entertained by 'Clumsy the Clown' at the annual Holiday Party in December. PHOTO: C. Ellis

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