Boston University's 2009 SPS Zone 1 Meeting

Panelist Bios and Student Abstracts

Boston University’s 2009 SPS Zone 1 Meeting
Career Panelist Bios:

Dr. Terry Russell

Dr. Russell is an experienced entrepreneur and scientist. He is currently the President and Chief Executive Officer of Makoto Life Sciences, Inc., (www.makotolife.com) a biotechnology company, focused on the identification of novel pharmaceutical targets in oncology, urology, and allergic inflammation. Dr. Russell is also a founder of Critical Biologics Corporation, a critical care pharmaceuticals company. Previously, Dr. Russell co-founded Vevionics, LLC, an engineering research and design company that develops innovative technologies for industrial process control and measurement. He was also the founder of LifeBeam Technologies, Inc., high-speed genomics technology company where he was the inventor of LifeBeam's patented core DNA sequencing technology. In addition to his entrepreneurial efforts, Dr. Russell has conducted research at Harvard University and Boston University on a wide range of topics; from detectors for biological warfare agents to genetically engineered proteins used in anti-counterfeiting applications. Dr. Russell is the Managing Partner of Zensei Analytics, LLC, a Boston-based new venture creation and consulting company. He holds a PhD in Physics from Boston University.

Dr. William D. Herzog

Dr. William Herzog has been a technical staff member in the Laser Technology and Applications group at Massachusetts Institute of Technology, Lincoln Laboratory (MIT-LL) for nine years. MIT-LL is a Department of Defense federally funded research and development center chartered to apply advanced technology to problems of national security. His work focuses on applying optical spectroscopy to aerosol detection and discrimination in order to develop sensors to detect airborne pathogens such as anthrax.

He currently leads two projects at the lab. The first involves a large team of engineers working to transition technology they developed to industry for insertion into a military defense system. His second project is researching how to apply vibrational spectroscopy to aerosol detection.

His background is predominately in experimental semiconductor physics and spectroscopy. He received a bachelor’s degree in physics from The College of William and Mary in Virginia. While an undergraduate, he worked for a semester in the x-ray scattering group at Brookhaven National Lab. He also worked in the experimental medium-energy physics group at the MIT-Bates accelerator and a in a pulsed NMR lab at William and Mary. He received his master’s degree in physics at Boston University while working in a low-temperature semiconductor spectroscopy lab. Finally, he received his doctorate in electrical engineering from Boston University in 2000 while working on novel approaches to characterizing semiconductor lasers and laser materials.

Professor Tulika Bose

Professor Tulika Bose (Boston University) received her Ph.D. in experimental high energy physics from Columbia University in 2006. Her post-doctoral research at Brown University focused on direct searches for new phenomena at the D0 experiment at the Fermilab Tevatron and at the Compact Muon Solenoid (CMS) experiment at the CERN Large Hadron Collider. She has also extensively worked on trigger and data acquisition for both D0 and CMS and is currently serving as the convener of the Trigger Menu Integration group at CMS. She is an author of numerous publications in refereed journals and is actively involved in preparations to extract physics from CMS using early LHC data.

Dr. Thomas Olsen

Dr. Thomas Olsen, former physics department chair at Lewis and Clark College in Portland, Oregon, is currently the Assistant Director of the Society of Physics Students (SPS) and for Sigma Pi Sigma, the physics honor society. An expert on chaotic patterns in fluid flow, he is now focusing his attention on developing new resources for physics bachelor's degree recipients as they plan their career trajectories.

Dr. Olsen led his campus's chapter of SPS to numerous national awards, and in 2006, he was recognized as Teacher of the Year at Lewis and Clark College. He has served on the SPS national Council for nearly two decades, first as the faculty representative from Zone 17 (Northwest US), and then as the President of Sigma Pi Sigma from 1998-2002. He is currently the SPS national Historian.

In 2004, he served as Program Chair of the Quadrennial Congress of Sigma Pi Sigma, and has been instrumental in planning the 2008 Congress held at FermiLab, IL. He has also served as President of the Oregon Section of the American Association of Physics Teachers and currently serves as Secretary/Treasurer of the Northwest Section of the American Physical Society. Dr. Olsen has garnered over a quarter of a million dollars in research grant funding, and led numerous students and high-school teachers in research projects ranging from vortex flow dynamics to measurements of eclipsing binary star systems.

Olsen received his BS degrees in Physics and Mathematics from Massachusetts Institute of Technology, and his MS and PhD in physics from University of Southern California.

Boston University’s 2009 SPS Zone 1 Meeting
Graduate Student Panelist Bios:

Adam Avakian

Adam Avakian graduated from Brown University in 2004 with an Sc.B. in Mathematics Physics. Deciding that he wanted to take a break from school, he took a job offer with Bank of America as a quantitative analyst in San Francisco. Despite college professors discouraging him from taking more than year or two off before attending grad school, he spent two years with Bank of America and a third year in New York working as a tutor before enrolling in the Boston University Ph.D. program in the fall of 2007. After almost two years back in physics, he has no regrets about taking the time off and is currently working with the Intermediate Energy Experimental Group on the nEDM (Neutron Electric Dipole Moment) experiment, though he has plans to start working with the Particle Theory Group this summer. You can contact him at avakian@bu.edu with any questions about his experiences, especially how to take time off.

Fanny Dufour

Fanny is a high-energy experimentalist enjoying regular trips to Japan to work on the Super-Kamiokande detector and to study neutrinos. Originally from Switzerland, she did her undergrad in Belgium before coming to grad school in Boston. She's been here for the last 6 years and is about to defend her thesis, after which she will begin a post-doctoral position in Geneva. She will work on the neutrino experiment T2K while serving on a panel to determine the future of neutrino physics in Europe. Outside of work, she loves hiking far away from home (India, Russia, Argentina, and New Zealand) and sings in the BU symphonic chorus, proof that you do have a little bit of free time during grad school! You are welcome to contact Fanny, her email address is fdufour@bu.edu.

Jason St. John

Jason graduated in physics from Harvard in 2001, and gave up on doing physics. He spent the next five years resisting the pull of his childhood longing to become a particle physicist. First he worked full time in the physics department of Boston University, becoming a specialist in lecture demonstrations. Then he gradually enrolled, but as a grad student in experimental solid-state physics.

He finally saw the light and became a high-energy experimentalist. Jason spent the last year at CERN's Large Hadron Collider, where he is a graduate student on the Compact Muon Solenoid. His new friend is the tera-electron-volt, and his French is better than it was. He's easy to find at stjohn@bu.edu.

Mike Pavel

Michael Pavel is a third-year Astronomy Graduate Student at Boston University. He received his undergraduate degree from the University of Florida, where he helped develop cryogenic, near-infrared instrumentation for telescopes and studied stellar variability. His current research focuses on the Milky Way Galaxy's magnetic field and magnetic dynamo. He also studies the role magnetic fields play in modulating star formation. His email address is pavelmi@bu.edu.

Zach Hartwig

After earning his wings as an undergraduate at Boston University Physics, Zach Hartwig traveled all the way across the Charles River to become a graduate student at MIT's Plasma Science and Fusion Center (with a few years of bike racing and traveling in between). He works on the Alcator-C Mod Tokamak, where his research focuses on developing new diagnostic tools to investigate how materials and plasmas interact inside a fusion reactor. If you're his advisor, he's always researching; if you're anyone else, he can usually be found on a bike or behind a book. Zach can probably be reached at hartwig@mit.edu.

Rachele Dominguez

Rachele's love for physics began while studying philosophy at the College of William and Mary. After graduating in 2002, she left for physics graduate school at the University of Washington in Seattle, where she picked up her interest in teaching. After receiving her Masters, she left Seattle for Boston to join her husband and teach physics at a public charter school in Cambridge. She returned to physics graduate school in 2005 at Boston University and started doing theoretical and computational research on the kinetics of phase transitions. She had another jaunt into the world of teaching high school through the NSF GK12 program, which connects local high school teachers with science graduate students. She will graduate this summer, move to Bowling Green, KY with her husband and finally get a really big dog. Contact Rachele erdomi@bu.edu.

Boston University's 2009 SPS Zone 1 Meeting
Student Research Talks:

* Student talks will be strictly limited to 10 minutes, after which there will be 2 minutes for questions.

1. *Monte Carlo Simulations of a 111-Ising Dipolar Model on the Hyper-Kagomé Lattice*, Patrick Carter, *Connecticut State University*
2. *Exploring Strain Induced Superconductivity in Diamond Nanoresonators*, Adam Patch, *Boston University*
3. *Dinucleon Decay into Leptonic Modes at the Super-Kamiokande Detector*, Brian Henning, *Boston University*
4. *Exploring Grain Alignment Mechanisms in Giant Molecular Clouds using GPIPS*, Katie Jameson, *Boston University*
5. *Surface Absorption of Polymers*, Jessica Leach, *Boston University*
6. *Studying the Physical Behavior of the Capillary Plasma Electrode (CPE) discharge*, David Jacome, *Saint Peter's College*

Student Talk Abstracts:

Monte Carlo Simulations of a 111-Ising Dipolar Model on the Hyper-Kagomé Lattice, Patrick Carter, *Connecticut State University*

Motivated by the physics of dipolar spin ice, we investigate the hyper-kagomé lattice with 111-Ising spins. The hyper-kagomé lattice can be generated by a selective removal of one site per tetrahedron of the pyrochlore lattice to yield a lattice of corner-sharing triangles. The spin-1/2 Ir^{4+} ions of $Na_4I_3O_8$ represent an experimental realization of the hyper-kagomé structure. We report preliminary results from Monte Carlo simulations of the 111-Ising dipolar hyper-kagomé model, which represents a yet to be studied disorder-free limiting case of diluted spin ice.

Exploring Strain Induced Superconductivity in Diamond Nanoresonators, Adam Patch, *Boston University*

This project explores the dynamics of polycrystalline diamond resonators. At high temperatures (between 230 and 290 K), we have determined the frequency and dissipation scaling laws for doubly clamped beam resonators and identified the dominant dissipation mechanisms is this parameter space. At low temperatures (less than 40 mK - 6K), we have detected the effect of low-lying energy defects (two-level-systems) as the intrinsic dissipation source of polycrystalline resonators with resonance frequencies in the MHz range. By comparing our results with those from similar structures made of silicon and gallium arsenide we were able to identify universality trends for the dissipation and sound velocity behavior at low temperatures. We fabricate our nano-mechanical oscillators using standard e-beam lithography and surface nanomachining.

Dinucleon Decay into Leptonic Modes at the Super-Kamiokande Detector
Brian Henning, *Boston University*

I present research into a proton decay study using the Super-Kamiokande water Cherenkov detector in Kamioka, Japan. Within the Standard Model of Physics, baryon number is empirically observed to be a conserved quantity. However, grand unified theories and other theories beyond the Standard Model allow for violation of baryon number conservation.

I have studied dinucleon decay to two leptons (NN→*ll*) for a variety of (B-L) conserving and violating decay channels. I present a simple cuts-based analysis for searching for such decays in the Super-Kamiokande detector. The lifetime sensitivity for these decay channels is ~10^{33} years— more than two orders of magnitude longer than lifetime limits set by the Frejus experiment in 1992.

Exploring Grain Alignment Mechanisms in Giant Molecular Clouds using GPIPS,
Katie Jameson, *Boston University*

The linear polarization of starlight along a line of sight arises from the alignment of anisotropic dust grains with the local magnetic field direction. The exact process which aligns the dust grains with the local magnetic field is still unknown. However, an understanding of the alignment mechanism is necessary to be able to interpret polarization maps as tracers of the galactic magnetic field. Recent arguments suggest that radiative aligned torques (RATs) dominate alignment in giant molecular clouds (GMCs), including the infrared dark cloud cores (IRDCs) within them. To test RAT theory, a nearby GMC at (l = 53, b = 0) was chosen to be observed this past June as part of the Galactic Plane Infrared Polarization Survey (GPIPS). The cloud covers a 1 x 2 degree region of the galactic plane (~200 GPIPS field-of-views), and displays regions of varying extinction, morphology, and radiation environments as seen using the GLIMPSE, MIPS, and GRS 13CO data. With an average sampling of 100 stars per GPIPS field-of-view (10' x 10'), we expect ~20,000 stars will show detectable polarizations –a factor of ~600 greater than in previous polarimetric studies. A plot of degree of NIR polarization P(%) vs. I/Imax, found using GRS 13CO data, is ideal for comparison to the models of Cho & Lazarian (2005). Approximate Av values are found using the 2MASS color excesses, EH-K. This aids in the generation of a plot of P(%)/Av vs. Av in dark clouds, to compare to the results of Arce et al. (1998) to test the notion that grains are aligned only for a few skin-depths.

Surface Absorption of Polymers, Jessica Leach, *Boston University*

Many groups have attributed numerous efforts to reveal the relation between the glass transition temperature (Tg) of thin polymer films and their thicknesses. Inside the Keddie and Wallace studies while both seem to begin with the same set up they showed opposite results. Keddie et al. found that the Tg obviously decreased with decreasing film thickness, which is the opposite of what Wallace observed. Wallace then suggested that there may be oxidation of the substrate affecting Keddie's results but did not prove it. Our experiment focused on this possible surface change under the PS film. It was found that there would form a residue film on the substrate after the PS film was annealed and rinsed. The Time-of Flight Secondary Ion Mass Spectroscopy and X-ray Photon Spectroscopy experiment verified that the residue was made up of polystyrene species. Therefore, oxidation is not the reason for the difference in results between the Keddie and Wallace experiments.

Studying the Physical Behavior of the Capillary Plasma Electrode (CPE) discharge

David Jacome, *Saint Peter's College*

A capillary plasma electrode is a device that produces stable atmospheric pressure non-equilibrium plasmas. The (CPE) is similar to the dielectric-barrier discharge. Their defining common feature is the presence of dielectric layer that allows for charges generated in the gas to reach the conducting electrode surfaces without arcing. The difference between these two sources is that a CPE scheme leads to the situation where a plasma jet is formed. The plasma jet formation depends on the frequency and wattage. This CPE plasma has a wide range of application, such as the destruction of pollutants in a fluid, the generation of ozone, the pretreatment of air for modifying or improving combustion, and the destruction of various organic compounds, and surface cleaning of objects. For these reasons, it's important to understand the CPE, mostly the formation is unique. We are focused on studying the behavior of the CPE is what has been correlated as the jet mode. Using optical emission spectroscopy is a crucial step to understanding the characteristics and formation of the CPE. The frequency, flow rate and the electrical power were measured. As you increase the electrical power, the plasma starts to lose stability. This occurs at a frequency range of 20 to105 kHz, going beyond 105 kHz, the CPE will not work. At higher frequencies, the plasma tends to need more power to turn on, so you observe it getting brighter. At lower frequencies, the plasma tends to use less power, therefore losing brightness.

Boston University's 2009 SPS Zone 1 Meeting Student Poster Presentations:

- *Exploring the Characteristics of Old Open Star Clusters*, Sadia Hoq, *Boston University*
- *The Fabrication and Electronic Properties of Graphene,* Andrea Welsh*, Boston University*
- *Electrical Aberrations in Graphene,* Chelsea Bartram, *Boston University*
- *Self-organization in Cathode Boundary Layer Discharge*, Luan Thieu To, *Saint Peter's College*
- *Measuring the Hydrogen Diffusitivity of the Anode and Cathode Layers of a Fuel Cell*, Ryan Eriksen, *Boston University*
- *The Use of a Lock-In Amplifier to Stabilize the Frequency of a Diode Laser,* Miguel Juarez, *College of the Holy Cross*
- *Studying the Physical Behavior of the Capillary Plasma Electrode (CPE) discharge*, David Jacome, *Saint Peter's College*
- *Using Dark Field Microscopy to Probe Subsurface Structures by Utilizing Fields from an Ideal Point Source Emitter*, Alex Krause, *Boston University*

Student Poster Abstracts:

The Fabrication and Electronic Properties of Graphene, Andrea Welsh, *Boston University*

Graphene, a single layer of graphite, is a substance that has unusual electric properties and, thus, is very promising for nanotechnology and other applications. Currently, we are finding more efficient methods of depositing, characterizing and locating so that we can eventually measure the Quantum Hall Effect in graphene sheets. This process requires multiple steps including a process called micromechanical cleavage and optical lithography to prepare the samples for measurements. However, this two-dimensional graphene surface is extremely sensitive to contamination. Annealing, the process of heating a graphene wafer by sending a current though, gets rid of excess contaminates on the wafer. With less dirt, the graphene wafer decreases in resistance, increasing the mobility of electrons across the graphene. Also, Raman spectroscopy measurements are able to give us more details about the effects that annealing has on the graphene samples by observing shifts in the 2D band as well as confirming the number of layers of our graphene sample.

Electrical Aberrations in Graphene, Chelsea Bartram, *Boston University*

I will be presenting research about graphene, and most specifically, how we gather good samples which can be used later in a variety of experiments. One of the biggest obstacles to working with graphene is finding it. Single layers of this two-dimensional material are difficult to identify. Currently, the most efficient means of acquiring graphene is to simply use scotch tape to deposit graphite (and hopefully, graphene) onto a silicon wafer. Then, the graphene can be identified using a microscope and optical contrast techniques. Optical Lithography and SEM are both viable means of contacting the graphene in order to run electrical experiments on this new conducting material;

Self-organization in Cathode Boundary Layer Discharge, Luan Thieu To, *Saint Peter's College*

Cathode Boundary Layer Discharge happens between a planar cathode and a ring-shape anode. The anode and the cathode are separated by a dielectric layer (250 mm in thickness). The anode foil and the dielectric layer have concentric circular openings with a diameter of 0.75 mm. Due to the short electrode-electrode separation, the discharge is restricted to mainly cathode fall and negative glow. When working in xenon at elevated pressures (>100 Torr), CBL discharge is a strong source of excimer emission (at 172 nm for xenon). When lowering the current to a critical value, self-organized patterns are formed on certain materials (e.g., molybdenum, titanium, hafnium, tungsten). Studying the self-organized patterns with different cathode materials and at various pressures helps better understand the mechanism of this phenomenon

Measuring the Hydrogen Diffusivity of the Anode and Cathode Layers of a Fuel Cell, Ryan Eriksen, *Boston University*

The goal of the project is to measure the oxygen diffusivity at elevated temperatures of the porous nickel anode substrates and $(LaCa)MnO_3$ (LCM) cathode substrates that are used in hydrogen fuel cells. The setup uses the oxygen ion transport abilities of Yttrium Stabilized Zirconia (YSZ). When a current is supplied across YSZ, it will transport the oxygen ions through the material, but it allows no other gas to diffuse through. The setup consists of a YSZ tube capped at one end with the porous substrate to be tested, and capped at the other end with a YSZ disc. The disc is fitted with two electrodes on either side to supply a DC current. When a DC current is supplied in the proper direction, the oxygen is evacuated from the chamber inside the tube. This creates a lower partial pressure for oxygen in the chamber, and a pressure gradient across the porous substrate. Eventually, a steady state is achieved so that the oxygen being evacuated is equal to the oxygen diffusing through the substrate. By measuring the electrical potential across the YSZ tube, we can calculate the pressure gradient across the porous substrate. Since we control the oxygen evacuation rate with the current and we know pressure gradient and the area of the substrate, the diffusivity of the substrate can be found. The cathode has two separate layers that must be tested separately using the same conditions as the anode, which only has one layer.

The Use of a Lock-In Amplifier to Stabilize the Frequency of a Diode Laser, Miguel Juarez, *College of the Holy Cross*

The lock-in amplifier is a versatile electronic device that is used in a wide range of physics experiments. It can detect, isolate, and amplify very small AC electrical signals that may be buried in substantial amounts of electrical noise. We have designed, constructed, and tested a lock-in amplifier built with readily available electronic components and homebuilt analog circuits. In our presentation, the various components of our lock-in amplifier are discussed and the basic principles behind the function and operation of this device are explained. We have used the output signal from our lock-in amplifier in a negative feedback loop to stabilize the frequency of a diode laser to an atomic transition in Lithium. The performance of our lock-in amplifier is comparable to that of a commercial unit, but it costs significantly less and is much more compact. We have also assembled a second diode laser system and are in the process of stabilizing it's frequency to a molecular transition in Iodine. To do this, we will use saturation absorption spectroscopy. We will explain the principle of this technique and present our latest results.

Studying the Physical Behavior of the Capillary Plasma Electrode (CPE) discharge, David Jacome, *Saint Peter's College*

A capillary plasma electrode is a device that produces stable atmospheric pressure non-equilibrium plasmas. The (CPE) is similar to the dielectric-barrier discharge. Their defining common feature is the presence of dielectric layer that allows for charges generated in the gas to reach the conducting electrode surfaces without arcing. The difference between these two sources is that a CPE scheme leads to the situation where a plasma jet is formed. The plasma jet formation depends on the frequency and wattage. This CPE plasma has a wide range of application, such as the destruction of pollutants in a fluid, the generation of ozone, the pretreatment of air for modifying or improving combustion, and the destruction of various organic compounds, and surface cleaning of objects. For these reasons, it's important to understand the CPE, mostly the formation is unique. We are focused on studying the behavior of the CPE is what has been correlated as the jet mode. Using optical emission spectroscopy is a crucial step to understanding the characteristics and formation of the CPE. The frequency, flow rate and the electrical power were measured. As you increase the electrical power, the plasma starts to lose stability. This occurs at a frequency range of 20 to105 kHz, going beyond 105 kHz, the CPE will not work. At higher frequencies, the plasma tends to need more power to turn on, so you observe it getting brighter. At lower frequencies, the plasma tends to use less power, therefore losing brightness.

Using Dark Field Microscopy to Probe Subsurface Structures by Utilizing Fields from an Ideal Point Source Emitter, Alex Krause, *Boston University*

We have constructed a fiber coupled laser darkfield (LDF) microscope to study its Point Spread Function (PSF) using nano-meter sized gold spheres as point sources. When illuminated, these gold spheres exhibit such strong scattering behavior, due to wavelength-dependent plasmon resonances, that a single 90nm sphere is clearly visible. Due to their small size, the scattered radiation fields are well described by dipole scattering. Furthermore, the scattering from gold particles exhibits no blinking or bleaching, making them real-world examples of the ideal point source that is the basis for evaluating the PSF. However, in a wide field imaging configuration we have found that the images of these particles seem to be missing their central maxima. Instead of seeing the typical airy-disk with a bright center surrounded by varying bands of dark/light, we see a dark center point and the first maxima is a hollow ring of light. This behavior is ascribed to the scattered dipole fields interfering with the dipole image of the particle induced in the substrate. When depositing these nanoparticles on a Si wafer with varying widths of Si02 on top, we see clear changes in the dark center behavior. This dependence of the point image on the intervening substrate thickness could allow for novel subsurface sensing techniques based on LDF illumination schemes. Since darkfield (DF) microscopes have the ability to exclude surface specular reflections from image formation, they have been used specifically for surface imaging. The interference effects in this LDF microscope allows exploration of sub-surface structures.