SOCIETY OF PHYSICS STUDENTS

Spring 2018 Society of Physics Students Zone 8 Meeting

February 23-24, 2018 at the Loomis Laboratory of Physics, University of Illinois at Urbana-Champaign

Message from the Head

On behalf of the nearly 800 physicists and future physicists of the Department of Physics at the University of Illinois at Urbana-Champaign, it is my great pleasure to welcome you to our campus and our community. Physics has been studied at the University of Illinois since its founding in 1867, and our faculty and students have made profound contributions to our discipline, from inventing the transistor to elucidating the eating habits of neutron stars.

Eleven people who worked and studied in our department have won Nobel Prizes in Physics and two have won Nobel Prizes in Physiology or Medicine; you'll be fortunate enough to hear from one of them tomorrow.

Enjoy your time with us. Ask lots of questions and network with your colleagues and our faculty. Get to know one another—there are no strangers in Loomis Laboratory of Physics.

I hope if your career plans include physics graduate school, you'll consider coming back to Urbana. We think it's the best place in the world to do Physics

Dale J. Van Harlingen, Head

Willett Professor of Physics

Schedule

Friday, February 23

2:30 - 5:30 p.m. | Check in | Loomis Lobby

-- Optional lab tours during this time --

5:30 - 6:00 p.m. | Welcome Address | 151 Loomis

-- Group photo at the end --

6:00 - 7:00 p.m. | Dinner catered by Monical's | Loomis 204

-- LN2 Ice Cream ! --

7:00 - 9:00 p.m. | Group Activities | 204 Loomis

Saturday, February 24

8:00 - 9:00 a.m. | Breakfast | Loomis Lobby

-- Late check in during this time as well as poster set-up --

9:00 - 11:00 a.m. | Graduate School Presentation & Panel | 151 Loomis

-- Bring your questions about grad school to this! --

11:00 - 12:00 p.m. | Speaker: Professor Tony Leggett | 151 Loomis

12:00 - 1:30 p.m. | Lunch | Around Town

1:45 - 3:00 p.m. | Student Talks Part 1 | Loomis 151

3:00 - 4:30 p.m. | Careers Talk | Loomis 151

4:30 - 5:00 p.m. | Break

5:00 - 6:00 p.m. | Student Talks Part 2 | Loomis 151

6:00 - 7:15 p.m. | Poster Presentations | Hallway outside Loomis 144

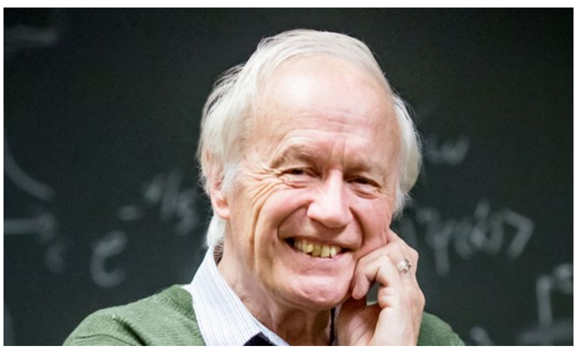
7:30 - 8:30 p.m. | Dinner | Loomis 204

8:30 p.m. | Closing Remarks + Goodbye | Loomis 151

Faculty Speaker

Anthony J. Leggett

Anthony J. Leggett attended Balliol College, Oxford, where he majored in Literae Humaniores (classical languages and literature, philosophy, and Greco-Roman history) and Merton College, Oxford, where he took a second undergraduate degree in physics. He completed a D.Phil. degree in theoretical physics at Oxford in 1964, and came to the University of Illinois as a postdoctoral research associate (1964-1965). After further postdoctoral positions at Kyoto University, Oxford, and Harvard, he joined the faculty of the University of Sussex in 1967. In 1983, he returned to Illinois as the John D. and Catherine T. MacArthur Professor of Physics.



Professor Leggett has shaped the theoretical understanding of normal and superfluid helium liquids and other strongly coupled superfluids. He has set directions for research in the quantum physics of macroscopic dissipative systems and use of condensed systems to test the foundations of quantum mechanics. He has been particularly interested in the possibility of using special condensed matter systems to test the validity of extrapolation of the quantum formalism to the macroscopic level. His pioneering work on superfluidity was recognized by the 2003 Nobel Prize in Physics. He is a member of the National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences, the Russian Academy of Sciences, and is a Fellow of the Royal Society, the American Physical Society, and the American Institute of Physics. He is a recipient of the Wolf Prize, the Paul Dirac Medal and Prize, the Fritz London Memorial Award, and the Maxwell Medal and Prize, among many others. In 2004, Professor Leggett was knighted by Queen Elizabeth II "for services to Physics."

Graduate School Panel

Professor Lance Cooper is associate head for graduate programs and a professor of physics in the Department of Physics, University of Illinois at Urbana-Champaign. He has served on the Departmental graduate admissions committee for about 15 years, and he has chaired this committee for 9 years. His research involves optical studies of condensed matter systems under high pressures and magnetic fields.

The graduate school presentation will explore how to decide if grad school is the right path for you, the different aspects of the application process, how to be competitive during the application process, and how to choose the best grad school for you.

Our graduate student panel will feature a diverse group of UIUC physics grad students from all areas of physics research. Please come with questions about grad school and the grad student experience to get firsthand information from our grad students. Topics of interest are: deciding what grad school is right for you, career options after grad school, understanding the application process, how to get the most out of grad school visits, and a peek into the daily life of a physics grad student.

Rachael Mansbach is a sixth-year PhD candidate in Andy Ferguson's Lab, a professor in MatSE but the research done is closely related to computational biophysicists. Rachael did her undergraduate studies at Swarthmore College, a small liberal arts college about twenty minutes outside of Philadelphia. As for post-graduate plans, it looks as if she will be doing a postdoc at Los Alamos next year.

Luis Dejesusastacio is a 1st year PhD student interested in theoretical and experimental biophysics, currently rotating between different biophysics labs in the department. Luis was born and raised in Puerto Rico and also did his undergraduate studies, in physics, in Puerto Rico. He plans to continue working in academia as a professor and researcher, ideally in Puerto Rico, after his graduate studies at Illinois.

Christian Boyd did his undergrad studies at the University of Missouri - Columbia (Mizzou) in mathematics and physics. His undergrad research was loosely focused on cosmology in expanding spacetimes, mostly GR perturbation theory. He is now a 3rd year grad student working with Professor Philip Phillips in condensed matter theory, mostly utilizing AdS/CFT (or holography). According to Christian, the future is uncertain, since he enjoys what he is doing now, but is open to getting into the industry with things such as finance/consulting/etc.

Brianne Guttmann is a 7th year graduate student doing physics education research for Professor Tim Stelzer. She received her undergraduate degree in physics at Carleton College, a small liberal arts school, and plans to continue in academia after graduation, hopefully to advocate for equity in STEM fields.

Karmela Padavic is a fourth year graduate student in theoretical condensed matter and atomic, molecular and optical (AMO) physics. Prior to enrolling at the University of Illinois Urbana Champaign as a doctoral student, she completed Bachelor of Arts in Physics and Bachelor of Science in Mathematics degrees at the University of Chicago. During her time there, she wrote an honors thesis studying vortices and other topological defects in Bose-Einstein condensates under the guidance of Prof. Kathryn J. Levin. Her current advisor is Prof. Smitha Vishveshwara and their work so far has focused on exploring novel geometries, such as hollow three-dimensional shells, of ultracold superfluids and one-dimensional dimer and quasi-crystal models and their topological phase diagrams. Following the completion of her doctoral degree she is hoping to further pursue a career in academia, starting with a postdoctoral research position in an area of study related to ultracold physics theory and experiments.

Careers Talk

This talk will explore how physics majors can prepare in their undergraduate years for a job in industry. Main topics include Skill Building, Networking, Resume Design, Finding the right job, and Interviewing. Many parts of this talk will be interactive, so participants are encouraged to bring a laptop or tablet. The discussion will be led by Jacquelyn Schmidt, a UIUC junior in Engineering Physics and the 2017-2018 Vice-President of SPS.

Poster Presentations

Kristin Barton | Middle Tennessee State University

Numerical Study of Mott Metal-Insulator Transitions

Strongly-correlated electron systems present an important class of quantum materials, e.g. , the Mott insulators, high temperature superconductors, quantum magnetic materials. Despite being fundamentally important materials, these systems are among the most technologically promising materials of 21st century. They can be possibly used in energy transmission, energy storage and computer technologies. It has been found that the exotic properties and phase of matter emerging in these quantum systems stem from strong electron-electron interactions. The strong electron interactions responsible for the rich properties of correlated systems also make them difficult to study, since the standard mean-field or perturbative methods don't apply in strong correlation regimes. In this poster, we present the results for 2D metal-insulator Mott transition obtained using the Dynamical Mean Field Theory at its cluster extension. We present the temperature-interaction strength phase diagram with the corresponding spectral function characteristics. In future, we plan to extend this analysis to 2D electron systems where in addition to local also non-local electron-electron interactions are present.

Tara Skiba | University of Tennessee, Knoxville

Tracking Neutrinos at MicroBooNE

The MicroBooNE experiment at Fermilab is a 170-ton liquid-argon time projection chamber (LArTPC) that explores properties of fundamental particles called neutrinos. Neutrinos are the second most abundant particles in the Universe, yet due to their weak nature of interaction with matter, little is known for certain about these particles. While neutrinos are not directly detectable, their interactions with matter produce observable particles, whose signals can then be collected and studied. The LArTPC technology used by MicroBooNE provides neutrino interactions with unprecendent amount of detail. MicroBooNE primarily studies neutrino interactions from Fermilab's Booster Neutrino Beam and has been collecting data since 2015. This poster will introduce neutrinos and the MicroBooNE experiment along with a description of how neutrino interactions are detected using the LArTPC technology. Some beautiful images from MicroBooNE's recent data will also be shown.

Grace Sun | University of Illinois at Urbana-Champaign

Raman characterization of microcrystals grown on monolayer graphene

Strain can be calculated from graphene's Raman signatures, and can be used to measure the force exerted by crystals grown on graphene. To do so, monolayer graphene was transferred to a glass substrate, onto which titania microcrystals were deposited via micro-pipette or grown via chemical reaction under autoclave conditions. The resultant samples were Raman-characterized before and after crystal growth. Graphene initially delaminated from the glass substrate over the course of three days during the autoclave procedure, although the grown titania produced clearly defined spectroscopic signatures. Micro-pipette deposition also yielded similar quality spectra containing both graphene and titania, even though the microcrystals were too amorphous to be ideal.

Benjamin Kulas | Middle Tennessee State University

GMajor: a Geant4-based Monte Carlo model of the MAJORANA DEMONSTRATOR

The MAJORANA project seeks to observe neutrinoless double beta decay ($0\nu\beta\beta$), a hypothesized phenomenon in which two antineutrinos annihilate each other. The detection of $0\nu\beta\beta$ decay would confirm that neutrinos are Majorana particles, i.e. that neutrinos and antineutrinos are the same particle. The MAJORANA DEMONSTRATOR is an array of detectors searching for $0\nu\beta\beta$ located at the Sanford Underground Research Facility. The DEMONSTRATOR uses germanium both as the source of double beta decay and as a semiconductor detector. The DEMONSTRATOR is a proof of concept, designed to "demonstrate" that SURF has low enough backgrounds for a larger experiment to be viable. I used the high-energy physics software library Geant4 to design and begin development on a computer model of the DEMONSTRATOR called "GMajor," intended as a tool to facilitate the design process for the larger detector.

Sidney Lower | University of Illinois at Urbana-Champaign

The Density of Dusty Galaxies at High Redshift

I determined the density of dusty galaxies at high redshift with two samples of galaxies selected independent of redshift. The first sample is from a deep blank field of galaxies in the ALESS (ALMA LABOCA ECDFS Submillimeter Survey) survey, which have mostly photometric redshift estimates. The second sample of galaxies is from the South Pole Telescope (SPT) Submillimeter Galaxy (SMG) sample, which are strongly lensed. The SPT sample all have spectroscopic redshifts, but the volume of the survey is difficult to determine because of the effect of gravitational lensing selection. I calculate the co-moving volume between redshift intervals of the two surveys to determine the co-moving density of the highest redshift dusty sources. From this, I come to the conclusion that there are 5 sources per deg^2. I then take these same SPT high-z sources and calculate dust masses, dust temperatures, and infrared luminosities from their SEDs, taking into account the magnification effects from gravitational lensing, and compare them to sources from the literature.

Kevin Kleiner | University of Tennessee Knoxville

Analyzing the Efficiency of a Metropolis Monte Carlo Simulation for a 2D Ising Spin Lattice

Monte Carlo programs can simulate the stochastic behavior of many-body atomic systems over time and reproduce the system's observable electrical and magnetic properties. This numerical simulation was implemented for a square Ising lattice of interacting atomic spins to collect independent measurements of the crystal's magnetization at varying times. The simulation ran for the ferromagnetic crystal phase (ordered spin directions) and paramagnetic crystal phase (unordered spin directions) with the boundary dictated by a critical temperature. Due to the stochastic updating algorithm for the spin sites, one system state was strongly correlated with the next state. To retain the validity of the magnetization average and variance calculations and minimize their bias, the simulation needed to only collect data when the states were nearly uncorrelated. Autocorrelation analyses gave insight into the amount of correlation between one site's spin value and that same site's spin value a certain time later. Evidently, the time steps required for the 30x30 (dimensions in site numbers) lattice's spin autocorrelation to drop below 10% ranged from ~20 steps when far from the critical temperature to ~200 steps when very close to the critical temperature. This slowing effect was compounded with larger system sizes since the Metropolis spin flip proposal algorithm was needed for more sites. The next step to improve the Monte Carlo simulation efficiency is to train a neural network to more quickly calculate the probabilities of flipping spins on the lattice.

Student Research Talks, Pt. 1

1:45 p.m. | Sidney Lower

The Infrared-Radio Correlation of Dusty Star Forming Galaxies at High Redshift

Far-infrared (FIR) and radio continuum emission in galaxies are related by a common origin: massive stars and the processes triggered during their birth, lifetime, and death. FIR emission is produced by cool dust, heated by the absorption of UV emission from massive stars, which is then re-emitted in the FIR. Thermal free-free radiation emitted from HII regions dominates the spectral energy density (SED) of galaxies at roughly 30GHz, while non-thermal synchrotron radiation dominates at lower frequencies. At low redshift, the infrared radio correlation (IRC, or q_IR) holds as a tight empirical relation for many star forming galaxy types, but until recently, there has not been sensitive enough radio observations to extend this relation to higher redshifts. Many selection biases cloud the results of these analyses, leaving the evolution of the IRC with redshift ambiguous. In this poster, I present CIGALE fitted spectral energy distributions (SEDs) for 24 gravitationally-lensed sources selected in the mm-wave from the South Pole Telescope (SPT) survey. I fit the IRC from infrared and submillimeter fluxes obtained with Herschel, Atacama Pathfinder Experiment (APEX), and SPT and radio fluxes obtained with ATCA at 2.1, 5.5, and 9, and 30 GHz. This sample of SPT sources has a spectroscopic redshift range of $2.1<z<5.7$ with an average redshift of $z=4$. In this talk, I will present the results of this study and compare our results to various results in the literature.

2:05 p.m. | Niko Urriola

Evolution of Eukaryotic Genome as a Consequence of Retroelements

Eukaryotic genomes are more complex than bacterial genomes. This difference is largely due to the presence of mobile genetic elements called retrotransposons. The human genome is ~80% retrotransposons whereas, retrotransposons are found in only ~30% of all sequenced bacterial genomes. Retrotransposons have the ability to copy and paste themselves throughout a host genome. The main goal of this research is to understand the forces that determined a high proliferation of retrotransposons in eukaryotes against bacteria. A human retrotransposon is transferred into Escherichia coli (E. coli), the activity of this bacteria is monitored and compared against the activity of a bacterial retrotransposon in the same strain. The results show that retrotransposon proliferation is detrimental to bacteria growth rate and enhanced by the presence of DNA repair mechanisms unique to eukaryotes.

2:25 p.m. | Peyton Nanney

Synthesis of Ruddlesden-Popper Strontium Iridate Epitaxial Thin Films

We investigated the growth conditions conducive to synthesize Ruddlesden-Popper type $SrIrO_3$, Sr_2IrO_4, and $Sr_3Ir_2O_7$ epitaxial thin films via pulsed laser deposition (PLD). Many factors influence the thermodynamic interactions of the deposition and therefore, determines the material phase that is created. Through a systematic review of these growth conditions, we constructed a growth phase diagram that maps out conditions that enable stable formation of strontium iridate phases. We synthesized these phases with a single Sr_2IrO_4 target with varying the O_2 chamber pressure and the substrate temperature. These films allow for the analysis of magnetic properties of the material through vibrating sample magnetometry and other methods. Our findings demonstrate the control of the thermodynamic stability of different epitaxial layered structure of the complex Ruddlesden-Popper family.

Student Research Talks, Pt. 2

5:00 p.m. | Alex Layton
Virtual Reality, Visual Cliffs, and Movement Disorders
We outline an experimental setup designed to dynamically understand neural responses to visual cliffs while walking. The goal of our work is understanding and mitigating fear of falling, particularly among the elderly. In our setup, an EEG cap monitors a subject's neural activity while the subject is immersed in a virtual world and walking on an instrumented treadmill. The subject's response to visual stimuli is measured by both the EEG cap and by speed and pressure data from the treadmill. Based on this data, we can dynamically alter the landscape in the virtual world. We hope that our setup may be useful in helping subjects develop mechanisms to compensate for significant fear of falling while walking.

5:20 p.m. | Damerrick Perry
The History of the Microscope
This presentation explores the development, history, and advancements of microscopy technology over time, as well as some of the contributions that have resulted from the applications of this machinery.

5:40 p.m. | Grace Sun | University of Illinois at Urbana-Champaign

Additional Information

Conference Contact and University Information

UIUC SPS Email: sps.at.illinois.edu

SPS Zone 8 Meeting Spring 2018 website: publish.illinois.edu/spszone8meeting2018/

University of Illinois at Urbana-Champaign physics department: physics.illinois.edu

Campus parking information: 217-333-3530

Campus Safety

University police non-emergency phone number: 217-333-1216

Carle Foundation Hospital: 217-383-3311

McKinley Health Center general information: 217-333-2701

In case of emergency, please dial 911.

In case of urgent conference-related questions or concerns, please contact Sidney Lower (UIUC SPS President) at 217-561-0774 or lower2@illinois.edu or Jacquelyn Schmidt (UIUS SPS Vice-Presidnet) at XXX-XXX-XXXX or jqschmi2@illinois.edu

We would like to thank the University of Illinois Department of Physics, Department Head Dale Van Harlingen, as well as the department staff and student volunteers.

Additionally we would like to thank the Society of Physics Students national arm.

All were crucial in making this event a success.

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