Wesleyan CUWiP Student Talks – Rms. 58, 109, 113, 121

There will be four rooms of student talks taking place at the same time. Please review the abstracts and select a session to attend. The abstracts appear in no particular order, but have been topically grouped where possible.

SESSION A: ROOM 121 EXLEY SCIENCE TOWER

Growth and Functionalization of MX2 Biosensors

Camilla Schneier - University of Pennsylvania

I study nanomaterial biosensors as a research assistant in the Johnson lab (Physics, University of Pennsylvania). Specifically, I've worked on growth, protein functionalization, and MOSFET transistor fabrication of monolayer MoS2 and WS2 nanomaterials. The purpose of this is to detect presence and concentration of various proteins that bind to the nanomaterials? surface, by taking current vs voltage measurements of the MOSFET. There are many steps to accomplish this: growth of the nanomaterial, fabrication of the transistor, functionalization of the protein, and device measurement. We report successful results.

Designing novel anti-inflammatory drugs by targeting the CD domain of the MAP kinase p38Î±

Kalina Slavkova - University of Pennsylvania

The activation of the kinase p38Î± initiates production of proinflammatory cytokines in the human innate immune response. Toxoplasma gondii, the parasite responsible for toxoplasmosis, targets this pathway by secreting a protein, GRA24, that binds the common docking (CD) domain of p38Î±, inducing autophosphorylation and thus implementing host immunity to regulate parasite population. This study reports on the structure and kinetics of the p38Î±-GRA24 complex and the purification of the natural activator of p38Î±, MEK6. In order to determine which regions of GRA24 interact with p38Î±, the complex was digested by four proteases followed by SDS-PAGE and mass spectrometry analysis. No predicted GRA24 fragments were found, suggesting that cutting-sites are inaccessible due to extended interaction beyond the known binding motifs. Further structural studies using X-ray crystallography were conducted using crystals of p38Î± and p38Î± bound to a synthetic peptide derived from GRA24 (GRA24IRD) hypothesized to be the shortest required sequence for binding and activation of p38Î±. Diffraction has been observed; though, more data is being gathered for conclusive results. Kinetics of the p38Î±-GRA24IRD complex were calculated with three trials of isothermal titration calorimetry. This yielded an average dissociation constant of 6.7 Î¼M, indicating strong affinity and many polar interactions. A radioactive assay confirmed induced autophosphorylation of p38Î±. Due to its high affinity for the p38Î± CD domain, the GRA24 binding motif was used to replace the analogous domain in MEK6 to stabilize the naturally transient interaction between MEK6 and p38Î± for purification and crystallization purposes, which are under way.

Teaching a Diverse History of Physics: African Americans in the Physical Sciences

Brean Prefontaine - Drexel University

Those in the STEM fields are often concerned about lack of diversity across the various disciplines and much discussion revolves around improving the situation. One aspect that is commonly overlooked is the place of women and minorities in the history of the physical sciences. In an effort to bring forth these stories, the American Institute of Physics Center for the History of Physics established the Women and Minorities Project in 2012 to encourage educators to incorporate these men and women into existing curriculum. The project has developed to encompass a variety of materials including a set of lesson plans and educational games that pertain to African Americans in the history of physical sciences. During the

summer of 2015, as a Society of Physics Student intern I expanded upon the materials pertaining to African Americans in order to provide more information to the student and to create an easier format for the instructor. I will introduce the Women and Minorities Project, discuss strategies used to develop the materials related to African Americans in the history of physical science, and share our vision for how the project will increase diversity in the physical sciences.

Metastable States in Terminal Orientation of Symmetric Bodies in a Flow

Doralia Castillod - Montclair State University

Symmetric bodies such as cylinders and spheroidal bodies, in their stable terminal state, are long known to have their long axis aligns itself perpendicular to the direction of the flow. This property has been verified theoretically, experimentally and numerically and the transition to a terminal stable state is believed to coincide with the onset of significant inertial effects in the flow. However, the threshold at which this transition occurs is yet to be determined. In this article we conduct an experimental study to examine the nature of the transition of prolate spheroids and cylinders of various aspect ratios, from initial to their terminal stable equilibrium. Specifically, our experiments reveal the presence of intermediate metastable states which are sensitive to the flow Reynolds number and gradually lead to the stable state. A phase diagram of Reynolds number versus non- dimensional inertia clearly demarcates the metastable, stable and oscillatory states that the bodies undergo in current and past studies.

SESSION B: ROOM 58 EXLEY SCIENCE TOWER

Investigation of Firewalls Inside the Event Horizon of Black Holes

Kallan Berglund - Brown University

I am conducting a literature review and mathematical investigation of the controversy surrounding firewalls inside the event horizon of black holes. Firewalls are a controversial attempt to solve the information paradox by suggesting a wall of heat existing inside the event horizon, providing energy to disentangle infalling particles. I am calculating what an observer would experience falling into a specifically constructed black hole, in order to determine whether the firewall constructed there is physically possible. This work is expected to invalidate a recently proposed method for constructing firewalls, while contributing to a larger body of evidence against the existence of firewalls in general.

Galaxy Masses, Star Formation Rates and Inclination

Betsy Hernandez - City University of New York Hunter College

We examine the inclination dependence of inferred star formation rates and galaxy mass estimates in the Sloan Digital Sky Survey by combining the disk/bulge de-convolved catalog of Simard et al 2011 with stellar mass estimates catalog of Mendel et al 2014 and star formation rates measured from spectra by Brinchmann et al 2004. We know that optical star formation indicators are reddened by dust, but calculated star formation rates and stellar mass estimates should account for this. However, we find that face-on galaxies have a higher calculated average star formation rates than edge-on galaxies. We also find edge-on galaxies have, on average, slightly smaller but similar estimated masses to face-on galaxies, suggesting that there are issues with the applied dust corrections for both models.

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Observation of the 2015 Occultation of Pluto
Rebecca Durst - Williams College

As part of a joint MIT-Williams research team, our group traveled to Mt. John University Observatory on New Zealand`s South Island to observe a stellar occultation by Pluto. Post-event analysis showed that we were around 55 km from the center line of the event. The occulted star had a magnitude in the red of 11.9 in a standard catalogue and a measured magnitude of 12.22, approximately 250 times fainter than the faintest star ever visible to the unaided eye (measured with the 61-inch US Naval Observatory telescope in Flagstaff, Arizona). According to the Royal Astronomical Society of New Zealand in 2014, Pluto`s magnitude is measure at R=14.3, making it approximately 10 times fainter than the occulted star. The brightness of the star and this difference in magnitude was so significant that we were able to operate our CCD camera at 10 Hz, meaning 10 images per second, giving us an exposure time of 0.1 seconds per image. This is the fastest speed at which we have run these cameras during an occultation.

Mapping Full-Extent Molecular Clouds
Jaquelin Erazo - City University of New York Hunter College

Massive and dense clouds of gas and dust support the birth of stars and solar systems. An outstanding difficulty is accurately and sensitively quantifying the mass and structure of the cloud. A dust cloud between an observer and a star not only scatters the light of the starlight and makes it fainter, but it also reddens the starlight. This effect is known as extinction. Extinction is wavelength dependent; shorter wavelengths are more preferentially scattered. Therefore, infrared bands (long wavelength colors) are used because we are able to ?look through? the dense areas of dust clouds and detect stars despite the extinction. However, infrared studies are only able to probe relatively high extinctions. To measure very low extinction regions, shorter wavelengths are preferred. We compare both a test field and a control field via stellar infrared and optical colors in order to find an optimal method that combines all available bands in detecting and quantifying extinction.

SESSION C: ROOM 109 EXLEY SCIENCE TOWER

Toward a Graphene-based Quantum Point Contact
Grace Pan - Yale University

Quantum point contacts (QPCs) are narrow constrictions on the order of the Fermi wavelength that bridge together two electrically conducting regions. QPCs display sensitive conductance quantization and are a classic playing field to illustrate clean, ballistic transport in low-dimensional materials. However, graphene-based QPCs are challenging to fabricate, in part due to two reasons: edge disorder that suppresses conductance quantization and imperfect gate depletion leading to charge puddles. Using graphene-boron nitride heterostructures, we demonstrate improvements over a simple etch and Au-gating method by introducing a protective alumina dielectric layer. We use this method to create two QPCs in series and explore potential electron-beam collimation at low magnetic field, in the spirit of Molenkamp (1990).

Trap State Measurements in Semiconducting Quantum Dots
Elizabeth Dresselhaus - University of Pennsylvania

Quantum dots (QDs) are nano-scale structures whose optical and electronic properties are highly dependent on their size. They exhibit strong photo absorbance in the solar range and have potential applications in photovoltaic cells. However, the conduction of these materials is poor in their current state. Trap states hamper charge flow and decrease power efficiency of QD devices. Quantifying the energy of the trap states may suggest new dopants to incorporate into devices. To this end, my

research uses Thermal Admittance Spectroscopy to quantify the trap state energies of PbS quantum dot films.

Geometrically Protected Resonance Modes and Optical Fano Resonances
Emma Regan - Wellesley College

Traditionally, photonic crystal slabs consist of a high-index guiding layer with periodic index contrast. These structures can support guided resonances that are strongly confined to the slab but can also couple to external radiation. The ability to channel light from the slab to the external environment has been used in optical devices, such as photonic-crystal-based light-emitting diodes. However, when a photonic crystal slab is placed on a substrate, the resonance modes couple to the substrate, reducing the interaction with external radiation. To avoid this problem, plasmonics and high-index dielectrics are used, but both are lossy, especially at short wavelength regime (such as visible wavelengths). Using the scale structure of the Diane Juno butterfly as inspiration, we present a low-index zigzag surface structure that supports guided resonance modes regardless of the substrate dielectric constant. We model an acrylic zigzag structure on various substrates using the finite difference time domain method. The resonance modes and corresponding Fano resonance peaks remain for substrate with large dielectric constants, which was not previously possible. The zigzag structure supports guided resonances that are contained away from the substrate, which reduces the coupling and geometrically protects the resonance modes. To experimentally verify the protected resonance property, the zigzag was used to generate structural color on a substrate with approximately equal dielectric constant. Zigzag structures were optimized to produce a Fano reflection peak in the visible spectrum and fabricated on a fused silica substrate using direct laser writing. Normal incidence reflection was measured with a microspectrometer and agrees well with predicted spectra, indicating that the resonance modes are geometrically protected by the zigzag structure.

SESSION D: ROOM 113 EXLEY SCIENCE TOWER

Quantum Minimax Strategies
Yihui Quek - Massachusetts Institute of Technology

In this talk, I treat Quantum State Estimation as a hypothesis testing problem and impose a loss function on various outcomes. Then I analytically solve for the optimal decision in various parameter regimes.

Creation Stories: Monty Python, Physics, and the Meaning of Life
Sierra Kozakar - Northeastern University

STEM majors have become more attractive and popular because they seem more easily transubstantiated into high-paying jobs in product development, technology, etc. There is something lost in this modern pursuit of economy. True philosophy, the love of knowledge, the search for knowledge for the sake of its intrinsic value, is sometimes lost. The magic is lost. I have chosen to study physics because I seek to find the meaning of life - nothing more, nothing less. Since I first began looking for meaning and purpose in my life, I have been looking for a beginning. I began with the beginnings of humanity, moved to the beginnings of Earth, and discovered in my early teens the beginnings of the universe. The Big Bang theory is based on evidence from red shift observed in faraway galaxies, cosmic microwave background radiation, and the abundance of elements in the universe. Theoretical models show physicists how the universe was forged in a chaotic harmony and probability, and it was born from that singularity of all matter and energy, space and time. This theory has implications for science

and the meaning of life. The vastness of the universe, the beauty of it, and the explosive, constantly changing nature inform humanity of its role in the grand scheme, as reflected in Monty Python's "Universe Song." However, there are many questions left unanswered. What is dark matter? What is dark energy? How did matter survive annihilation with antimatter? How do quantum mechanics and general relativity coexist when the entire universe is on the quantum scale? How will we find these answers, and how will humanity react to them? Investigation into the origins of the universe and the meaning of life cannot be commodified, but they must be pursued. This pursuit fills me with zeal and purpose. I vehemently urge other young women in physics to take a moment to look at the stars, look at the matter around them, and ask themselves what

Sterile Neutrino Searches with the NuSTAR High-Energy X-ray Telescope

Cora Hersh - Haverford College

Although scientists know that dark matter exists due to its gravitational effects on the structure and motion of objects in the universe, nobody has ever discovered a dark matter particle. The Standard Model of Particle Physics describes all the fundamental particles that have ever been found and how they interact with each other. A few "holes remain in the theory and some new theoretical particles proposed to fill those gaps are candidates for dark matter. One such particle is the sterile neutrino which would only directly interact with normal matter via gravity and would very occasionally decay to produce a regular neutrino and a photon. These photons could theoretically be seen above the normal background spectra of objects in the universe when observed with a telescope. The NuSTAR high-energy x-ray telescope is the first focusing telescope to observe in its energy range of 3-79 keV so its improved spatial resolution may lead to new discoveries in dark matter. Even if no extra photon peak is found that would indicate sterile neutrino decay limits can be placed on the particles` possible mass/strength of interaction. Using observations of the Milky Way center along with information about NuSTAR`s instrumental background and dark matter density profiles of galaxies preliminary bounds on sterile neutrino mass versus mixing angle (a.k.a. interaction strength) are being set. The limits on the characteristics of sterile neutrinos from NuSTAR observations are found to be competitive with previously-set limits. They may be narrowed further with less conservative estimates of the maximum photon flux from sterile neutrino decay for a given observation."