PHYSICS & ASTRONOMY

Undergraduate Research Conference 2009

Department of Physics & Astronomy

Scholar's Week

Tuesday, May 19, 2009, CF 386

Time	Presenter	Faculty Mentor	Topic
1:00 – 1:30 PM	David Sergio	Milton From	Mössbauer Spectroscopy
1:30 – 2:00 PM	Christy Tobin	Ken Rines	Star Formation
2:00 – 2:15 PM	Amanda Norell Bader	Janelle Leger	Quantum dots in Polymers
2:15 -2:30 PM	Cole Sekedat	Takele Seda	superparamagnetic nanoscale magnetite
BREAK			
3:00 – 3:30 PM	Shawn Divitt	Janelle Leger	plasmon-polariton modes in composite thin films
3:30 – 4:00 PM	Larz White	Andreas Riemann	Metallic thin films
4:00 – 4:15 PM	Britt Barquist	Jim Stewart	Meta-cognitive Student Reflections
4:15 – 4:30 PM	Dan Gifford	Ken Rines	Galaxy clusters
4:30 – 4:45	Scott Burger	Ken Rines	Galaxy formation

1:00 – 1:30PM **David Sergio:** Two Mössbauer Spectroscopy Topics: (i) The Necessity of Recoilless Absorption and, (ii) Absolute Velocity Measurements

(i) A pedagogical demonstration of the Mössbauer Effect is performed using the transition of an absorber from liquid to solid state. A temperature control cell was designed to hold the absorber as an aqueous solution. A Peltier thermoelectric device was used to control the temperature of the absorber. Ferrous Sulfate was used as an absorber because of its solubility in water. Two spectra were taken of the absorber: at room temperature and at slightly below the solution's melting point, and the results are analyzed. (ii) A research grade Mössbauer spectrometer was used together with a Michelson Interferometer to achieve an accurate velocity calibration of the spectrometer. A front surface mirror was attached to the moving platform inside the spectrometer. This mirror acted as one of the two Michelson interferometer mirrors. Interference fringes were detected with a laser power meter. Pulses from the meter were shaped by a comparator and then counted by a LabVIEW program. Simple algebra was used to convert count rates into absolute velocity measurements.

1:30 – 2:00PM **Christy Tobin:** Studying Star Formation in Galaxy Clusters with the Spitzer Space Telescope

Galaxy clusters are some of the biggest objects in the universe. They are made up of 10 to 100 galaxies which are each the size of our own Milky Way galaxy. By measuring the rate of star formation in clusters we can understand how the galaxies built up their stars over time. Dust surrounding star formation regions absorbs most of the optical light from young stars, so we need to observe the galaxies at longer wavelengths to see through the obscuring dust clouds. We use the Spitzer Space Telescope to observe mid-infrared light emitted by these galaxies in a sample of 41 clusters. The fluxes of mid-infrared light measure the star formation rates of the galaxies. We can then determine how these rates depend on the properties of the parent cluster. These data will help constrain models of galaxy evolution within clusters. Here we describe the process of transforming the raw data from the satellite into clean, calibrated images necessary for making these measurements.

2:00 – 2:15PM **Amanda Norell Bader:** Incorporation of quantum dots in polymer light-emitting electrochemical cells

Semiconducting polymers have enormous potential to expand the applications of electronic and optoelectronic technologies. Current inorganic semiconductors are expensive and limited, whereas polymer semiconductors are solution-processesable and can be deposited *via* screen printing or ink-jet printing, allowing inexpensive fabrication at low temperatures over large areas and on flexible substrates. Polymer optoelectronic devices, such as LEDs and solar cells, have been successful, but suffer from poor performance and stability. To circumvent this difficulty, a novel hybrid structure based on a polymer light-emitting electrochemical cell (LEC) incorporating colloidal quantum dots (semiconductor nanocrystals) is being pursued. Devices with quantum dots have been inefficient due to an insulating surface ligand layer, but the LEC structure limits the active layer thickness, reducing the charge tunneling barrier. Quantum dots were synthesized and included in polymer LEC structure with promising results. Current-voltage measurements and emission spectra of these devices were collected, showing better color purity in devices which incorporate quantum dots. This method has the potential for low cost and efficient hybrid LEDs and solar cells.

2:15 – 2:30PM **Cole Sekedat:** Colloid-synthesis and characterization of superparamagnetic nanoscale magnetite

We present preliminary results on the microemulsion synthesis of superparamagnetic nanoscale magnetite. Our goal is to generate nanoparticles between five and fifteen nanometers in diameter. Microemulsions are useful for synthesis because they produce small particles with a narrow size distribution. The purity of chemical precursors to magnetite is of paramount importance. We found that purification of precursors using vacuum filtration drying and washing ultimately produced pure magnetite, but with an average particle size of fifty five nanometers. We also found that significant surfactant concentrations at the time of the final reaction successfully generated a microemulsion, but resulted in a highly impure unusable substance. Using a different approach, we hope to create a colloidal suspension of precursor micelles, using only low temperature liquid phase purification to generate magnetite with a mean diameter of seven nanometers.

3:00 – 3:30PM **Shawn Divitt:** Composite thin films for low-loss energy transport utilizing guided-wave plasmon-polariton modes

The cost of current high-efficiency photovoltaic cell technology is prohibitive for many modern applications. Luminescent solar concentrators (LSCs) are a classic photovoltaic technology that is theoretically capable of high efficiency at low cost. Historically, however, energy transport losses within LSCs have led to low efficiencies. To achieve ultra-efficient energy transport we take advantage of plasmon-polariton modes within composite thin films. They can greatly reduce the reabsorption and scattering losses associated with traditional total internal reflection transport layers. I will discuss motivations for the project and recent results in film fabrication and testing.

3:30 – 4:00PM **Larz White:** Surface structure investigation of ultrathin Ni film growth on Ag(211)

Nanotechnology is a thriving and expanding field with surface science serving an integral role. Structural change of an underlying substrate resulting from the growth of metallic thin films is a crucial area of research in this field. Analysis of the effect thin films have on an underlying substrate has the potential for increasing the density of magnetic storage devices such as computer hard drives and iPods. Characterizing the surface structure is the first step in making such technological improvements. Low Energy Electron Diffraction (LEED) is a method used to define the surface structure. Information regarding the theory and calibration of LEED along with our experimental setup will be presented. As a substrate we used Ag(211). Thermal evaporation was used to deposit a thin film of magnetic nickel on the surface. Preliminary results for this experiment will be presented.

4:00 – 4:15 PM **Britt Barquist:** Meta-cognitive Student Reflections

We have recently concluded a project testing the effectiveness of a weekly assignment designed to encourage awareness and improvement of meta-cognitive skills. The project is based on the idea that successful problem solvers implement a meta-cognitive process in which they identify the specific concept they are struggling with, and then identify what they understand, what they don't understand, and what they need to know in order to resolve their problem. The assignment required the students to write an email assessing the level of completion of a weekly workbook assignment and to examine in detail their experiences regarding a specific topic they struggled with. The assignment guidelines were designed to coach them through this meta-cognitive process. We responded to most emails with advice for next week's assignment. Our data follow 12 students through a quarter consisting of 11 email assignments which were scored using a rubric based on the assignment guidelines. We found no correlation between rubric scores and final grades. We do have anecdotal evidence that the assignment was beneficial.

4:15 – 4:30PM **Dan Gifford:** Mass, Light, and Galaxy Number in Nearby Clusters

Galaxy clusters are excellent laboratories for studying the relation between galaxies and their environments. We use 39 galaxy clusters from the Cluster Infall Regions in the Sloan Digital Sky Survey (CIRS) project to study the mass to galaxy number ratios, measure mass to light ratios, and calculate mass to light profiles. These results will help us understand how galaxies populate dark matter halos and determine how star formation efficiency depends on environment. We use redshifts obtained from the Fourth Data Release of the Sloan Digital Sky Survey (SDSS), the NASA/IPAC Extragalactic Database (NED), and new redshifts obtained at the Fred Lawrence Whipple Observatory (FLWO) and couple them with photometric data from the SDSS to create clean galaxy catalogs for this study. Using this sample, we find that the mean number of bright galaxies populating a dark matter halo scales as $N \propto M^{0.65\pm0.06}$. This result indicates that low-mass clusters have more galaxies per unit mass than high-mass clusters. Similarly, the total light of bright member galaxies scales as $L \propto M^{0.59\pm0.06}$. These results generally agree with previous cluster studies that used different techniques for identifying members and for estimating masses. Finally, we present the mass-to-light profiles of each cluster. These profiles are generally flat at large radii, suggesting that the efficiency of star formation depends only weakly on environment.

4:30 – 4:45 PM **Scott Burger:** Using the Luminosity Function to Understand Galaxy Formation

Luminosity functions describe the distribution of intrinsic brightnesses (or luminosities) of galaxies. Dark matter halos are spherical distributions of non-luminous matter around a galaxy. Dark matter halos contain smaller dark matter subhalos, which can be described by a mass function. The slope of luminosity functions are closely tied to dark matter subhalo mass functions. We probe the faint-end luminosity functions of galaxy clusters and determine their parameters with use of the Sloan Digital Sky Survey Data Release 7. Because the surface brightness of galaxies increases with their luminosity, surface brightness can be used as a distance indicator and hence separate cluster members from background galaxies. We therefore search for irregular, low surface brightness galaxies which are likely to be group members. Combined with spectroscopically confirmed members, we use these galaxies to estimate the luminosity function of a nearby group. Wide spatial coverage will allow us to test whether the luminosity function is the same in the core and in the outskirts of the group. These data allow better modeling of the dependence of galaxy luminosity on dark matter halo mass, as well as provide strict constraints on models of galaxy formation and evolution.