Rochester, April 9, 2011

Dear Participants:

Welcome to the 30th annual Rochester Symposium for Physics Students (RSPS). The RSPS was instituted to provide an opportunity for undergraduates to present an account of their own personal research at a meeting whose format was chosen to closely resemble those of professional scientific societies.

At these symposia, research projects are presented in talks or poster sessions by undergraduates representing many regional institutions. Topics include condensed-matter physics, atomic physics and optics, computational physics, astronomy, particle and nuclear physics, instrumentation and techniques, environmental physics, biological physics, medical physics, and educational physics. The abstracts of all the participants' papers are published annually in the RSPS proceedings and distributed to the participants. The information is also available on line at

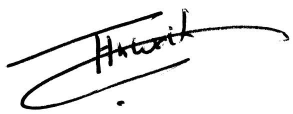
http://www.pas.rochester.edu/urpas/page/RSPS2011.

Students who present these talks can list their RSPS presentation(s) on their resumes and show the above web page in their list of publications as an "On-line Published Abstract". We encourage students to follow up on their research with the aim of giving a presentation at a regular APS meeting (which now also has a special session on undergraduate research), and eventually follow up with a publication in a regular journal, or in the APS Journal of Undergraduate Research.

At Rochester, the Department of Physics and Astronomy and the Institute of Optics are jointly running two National Science Foundation (NSF) funded Research Experience for Undergraduates (REU) sites. We encourage you to apply to one of these summer programs. Examples of research projects, talks, publications and awards won by our REU participants can be found on our REU Web page:

http://www.pas.rochester.edu/urpas/page/specialreu

Your audience will include both students and faculty members and will provide you with the opportunity to address a knowledgeable and appreciative assembly of fellow researchers. Scientific research is an extraordinary activity. We certainly hope that many of you will decide to pursue careers that involve you intimately in mankind's greatest intellectual adventure, to comprehend nature. To quote Albert Einstein, “The eternal mystery of the world is its comprehensibility.”



**Frank Wolfs (Chair RSPS)**
**Department of Physics and Astronomy**
**University of Rochester**

## LIST OF SPEAKERS

| NAME | TIME | LOCATION |
|---|---|---|
| Adams, Corey | 9:45 AM | B&L 106 |
| Albany, Virginia | 10:00 AM | B&L Lobby |
| Bandes, Steven | 1:45 PM | B&L 407 |
| Barenfeld, Scott | 10:00 AM | B&L Lobby |
| Bauch, Paul | 2:45 PM | B&L 106 |
| Bentsen, Gregory | 2:30 PM | B&L 407 |
| Bontorno, Anna | 9:00 AM | B&L 109 |
| Brown, Joshua | 10:30 AM | B&L 109 |
| Carroll, Robert | 2:15 PM | B&L 109 |
| Crawford, James | 11:00 AM | B&L 106 |
| DeHaas, Timothy | 10:00 AM | B&L Lobby |
| Del Belso, Kristin | 2:30 PM | B&L 109 |
| deLahunta, Daniel | 11:15 AM | B&L 106 |
| DeMatteo, John | 9:15 AM | B&L 109 |
| Dunn, Shaun | 9:45 AM | B&L 109 |
| Dunphy, Jon | 9:30 AM | B&L 109 |
| Fuller, Nicholas | 10:00 AM | B&L Lobby |
| Gaul, Andrew | 2:15 PM | B&L 407 |
| Geller, Joshua | 9:30 AM | B&L 106 |
| Gresh, Daniel | 10:00 AM | B&L Lobby |
| Held, Ryan | 2:00 PM | B&L 106 |
| Heuer, Peter | 1:45 PM | B&L 109 |
| Koehler, Katrina | 10:00 AM | B&L Lobby |
| Koehler, Katrina | 2:45 PM | B&L 109 |
| Kravec, Shane | 10:00 AM | B&L Lobby |
| Marcus, Colin | 2:15 PM | B&L 106 |
| Mihaylova, Dilyana | 2:00 PM | B&L 109 |
| Nelson, Rachel | 10:45 AM | B&L 106 |
| Novenstern, Matthew | 9:15 AM | B&L 106 |

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|---|---|---|
| Primrose, Joshua | 11:00 AM | B&L 109 |
| Quill, Dennis | 10:45 AM | B&L 109 |
| Reynolds, Tyler | 10:00 AM | B&L Lobby |
| Rutkowski, Todd | 1:45 PM | B&L 106 |
| Schubert, William | 9:00 AM | B&L 106 |
| Sheehan, Patrick | 10:00 AM | B&L Lobby |
| Silvernail, Adam | 2:00 PM | B&L 407 |
| Stewart, Mark | 2:45 PM | B&L 407 |
| Swartz, Stephanie | 10:00 AM | B&L Lobby |
| Swift, Nathan | 10:30 AM | B&L 106 |
| Whyte, Andrew | 2:30 PM | B&L 106 |

## XXX – ROCHESTER SYMPOSUM FOR PHYSICS (ASTRONOMY AND OPTICS) STUDENTS
## SPS ZONE 2 REGIONAL MEETING

## PROGRAM

### 8.15 AM – 8.45 AM: REGISTRATION AND POSTER SETUP (B&L LOBBY)

### 8.45 AM: WELCOME (B&L 109)

**Prof. Frank Wolfs**, University of Rochester.
**Prof. Eric Mamajek**, University of Rochester.

### 9:00 AM – 10.00 AM: SESSION IA. ASTRONOMY I (B&L 109)

**SESSION CHAIR: PROF. CHRISTOPHER WELLS (HOUGHTON COLLEGE)**

**9:00 Period-Color Relations at Maximum/Minimum Light for Sloan Digital Sky Survey RR Lyraes**
Anna Bontorno, SUNY Oswego

**9:15 System Development for Projecting Firefly's Orbit Location**
John DeMatteo, Siena College

**9:30 Searching for Life on Other Planets Using ANNs**
Jon Dunphy, Siena College

**9:45 Classifying Near Earth Asteroids**
Shaun Dunn, Siena College

### 9:00 AM – 10.00 AM: SESSION IB. QUANTUM OPTICS AND PLASMA PHYSICS (B&L 106)

**SESSION CHAIR: PROF. JOSEPH EBERLY (UNIVERSITY OF ROCHESTER)**

**9:00 Generation of Optical Vector Beams by Spatial Light Modulation**
William Schubert, Colgate University

**9:15 Creating more Qubits with Spatial Mode Entanglement**
Matthew Novenstern, Colgate University

**9:30 Search for an Entanglement Measure for N-Qubit States via Phase Symmetry**
Joshua Geller, University of Rochester

**9:45 Laser Induced Florescence Measurement of Ion Temperatures of Interacting Magnetic Flux Ropes in Argon Plasma**
Corey Adams, University of Rochester

**10.00 AM – 10.30 AM: SESSION II. POSTER SESSION (LOBBY B&L)**

**Improved design for a multibeam femtosecond Yb:KGW oscillator**
Virginia Albany, U.S. Military Academy at West Point

**Analysis of GALFACTS Data for the Study of Variable Radio Sources**
Scott, Barenfeld, University of Rochester

**Monitoring of spectral emissions using the Compact Spectrometer Array diagnostic on NSTX**
Timothy DeHaas, University of Rochester

**The NIFFTE TPC Gas Handling System,**
Nicholas Fuller, Houghton College

**Design and Implementation of a Timing Control System for use in a Bose-Einstein Condensate (BEC) Experiment**
Daniel Gresh, University of Rochester

**Deuteron Formation for Big Bang Nucleosynthesis Models**
Katrina Koehler, Houghton College

**Localization of a Hole on an Adenine-Thymine Radical Cation in B-Form DNA in Water**
Shane Kravec, University of Rochester

**The Design and Construction of a Deposition Chamber and Laser Interferometer for the Study of Thin Metal Films**
Tyler Reynolds, Houghton College

**Accretion Processes in Class 0/I Protostars**
Patrick Sheehan, University of Rochester

**Atomic Layer Deposition of $TiO_2$ Thin Films**
Stephanie Swartz, University of Rochester

**10:30 AM – 11.15 AM: SESSION IIIA. ASTRONOMY II (B&L 109)**

**SESSION CHAIR: PROF. DALE ZYCH (SUNY OSWEGO)**

**10:30 The development of photometry/extinction/database modules for the Chimera Robotic Telescope System**
Joshua Brown, University of Rochester

**10:45 Calibration routines for the Chimera Robotic Telescope Control System**
Dennis Quill, SUNY Oswego

**11:00 Sample Images from the Chimera Robotic Telescope Control System: summer 2010**
Joshua Primrose, SUNY Oswego

**10:30 AM – 11.30 AM: SESSION IIIB. BIOLOGICAL/MEDICAL PHYSICS (B&L 106)**

**SESSION CHAIR: PROF. MARK YULY (HOUGHTON COLLEGE)**

**10:30 Biomineral Structure and Strength of Barnacle Exoskeletons**
Nathan Swift, Colgate University

**10:45 The Effect of Ultraviolet Sunlight on the Survival of e. Coli: Disassembling Existent Biofilms**
Rachel Nelson, Siena College

**11:00 Cell Classification based on Artificial Neural Networks**
James Crawford, Siena College

**11:15 MR Spectroscopic Imaging with MIDAS and Matlab**
Daniel deLahunta, University of Rochester

**11.45 AM: LUNCH (MELIORA, SALON D)**

**12.45 PM: PHYSICS JEOPARDY (B&L 109)**

**1.45 PM – 3.00 PM: SESSION IVA. CONDENSED MATTER PHYSICS (B&L 407)**

**SESSION CHAIR: PROF. BRANDON HOFFMAN (HOUGHTON COLLEGE)**

**1:45 Anomalous diffusion of random walkers on a disordered lattice with quenched persistence**
Steven Bandes, University of Rochester

**2:00 Controlling the Sample Temperature in a Vacuum Thin Film Deposition Chamber**
Adam Silvernail, Houghton College

**2:15 Indium Thin Film XRD Characterization and Electrical Analysis**
Andrew Gaul, The College at Brockport

**2:30 The Kondo Problem: A Toy Model for Renormalization**
Gregory Bentsen, University of Rochester

**2:45 Water Desorption from Various Ferroelectric and Dipole Oriented Polymers**
Mark Stewart, SUNY Oswego

**1.45 PM – 3.00 PM: SESSION IVB. NUCLEAR AND PARTICLE PHYSICS (B&L 109)**

**SESSION CHAIR: PROF. JOHN CUMMINGS (SIENNA COLLEGE)**

**1:45 Design and Construction of a Compact 2 MeV Proton Cyclotron - "The Cyclotron Kids"**
Peter Heuer, Thomas Jefferson National Accelerator Facility

**2:00 Designing an algorithm for a three-dimensional Hough transform of the reconstruction of low-energy events**
Dilyana Mihaylova, University of Rochester,

**2:15 Particle Detector Design Using Delay Line Technique to Determine Anode Position**
Robert Carroll, Siena College

**2:30 Siena's Muon Detector**
Kristin Del Belso, Siena College

**2:45 Neutron-Induced Deuteron Breakup**
Katrina Koehler, Houghton College

**1.45 PM – 3.00 PM: SESSION IVC. EXPERIMENTAL TECHNIQUES (B&L 106)**

**SESSION CHAIR: PROF. JOHNSON-STEIGELMAN (THE COLLEGE AT BROCKPORT)**

**1:45 A Mutual Inductance Bridge for Electric and Magnetic Measurements**
Todd Rutkowski, The College at Brockport

**2:00 Comparative Studies of electrical and mechanical Chaotic Systems**
Ryan Held, The College at Brockport

**2:15 Dynamics of a Plasma Gun**
Colin Marcus, University of Rochester

**2:30 Using a Star to See Stars**
Andrew Whyte, Siena College

**2:45 Room Acoustics - Measurement and Analysis**
Paul Bauch, The College at Brockport

**3.30 PM: TOUR LLE (OPTIONAL)**

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## SESSION IA. ASTRONOMY I

### Period-Color Relations at Maximum/Minimum Light for Sloan Digital Sky Survey RR Lyraes

A. Bontorno, M. Berke, C. Phelps, C. Ngeow, and S. Kanbur
SUNY Oswego and National Central University, Taiwan

We present period-color relations at maximum/minimum light for RR Lyraes observed in the Sloan Digital Sky Survey (SDDS). The survey has resulted in significant amounts of new data, especially for RR Lyrae stars. We analyzed a sample of RR Lyraes, observed by the SDDS, and used light curve template methods to reconstruct period-color relations at maximum/minimum light. Such relations are useful to determine astrophysical reddening.

### System Development for Projecting Firefly's Orbit Location

John DeMatteo and Dr. Allan Weatherwax
Siena College

Once launched into orbit, having access to the latest orbital data of NASA's picosatellite Firefly Cubesat, will be imperative. We have developed a stand-alone computer program, utilizing Matlab and AGI's Satellite Tool Kit (STK), to create an automated process that obtains the latest known orbital information from Firefly and uses the STK to project an estimated orbit of the satellite. It is important to know where Firefly will be in order to determine what components on board of the satellite to use and when to use them. Matlab was used to read in a two-line element with orbital information from the satellite, send this information to the STK, use the STK to project where Firefly will be, and finally send this information to a server where the information can be readily accessed. Implementation of these objectives required computer software development, implementation, and debugging. Firefly now has a reliable, automated system, ready to calculate and project where it will be in orbit at all times.

### Searching for Life on Other Planets Using ANNs

Jon Dunphy and Dr. Theodore von Hippel
Siena College

In the near future, NASA will be launching a project to search for terrestrial planets in nearby planetary system in hopes of finding other forms of life. In order to equip the craft sent to search for these planets, we conducted a computational study on many different ideal spectra of various planets in our solar system. We manipulated all portions of the ideal spectra, including resolution, signal-to-noise ratio, and the type of noise added to the signal. To classify these manipulated spectra, we used Artificial Neural Networks (ANNs) to emulate the process of observing distant planets. We manipulated portions of the neural networks, such as the training method, number of nodes, and the wavelength range of the spectra being studied. As we feed the neural network noisy spectra, we know what it is that the ANN trying to classify. Based on the results of this classification, we can determine the performance requirements of the technology that would be used by NASA to search for terrestrial planets.

**Classifying Near Earth Asteroids**

Shaun Dunn and Dr. Rose Finn
Siena College

We classify asteroids into three categories: type C, type S, and type X. Type C asteroids are carbon based and the most common. Type S asteroids are primarily made of silicon-based material. The final class of asteroids is the least common. They contain any material that is not carbon or silicon based. We can determine asteroid class based on reflectivity of light, denoted as the albedo. The albedo varies within the classes; type S asteroids have higher albedos than type C asteroids. Most of these near earth asteroids populate the Kuiper belt in our solar system. I use a CCD camera to image an asteroid with different filters. Using the Minor Planet Observatory software for Windows, I will find an asteroid to image. The flux will be determined from the CCD images obtained with the three filters. Using these flux values I will graph the color values. From the chart I will be able to determine the asteroids class. The chart that I reference is a graph obtained from my adviser, Dr. Finn, and can be found at http://www.naic.edu/~ehowell/filterphot.html. The final goal of the project is to successfully classify an imaged asteroid, as well as test the limits of our observing telescope.

## SESSION IB. QUANTUM OPTICS AND PLASMA PHYSICS

### Generation of Optical Vector Beams by Spatial Light Modulation

Enrique Galvez and William Schubert
Colgate University

We have developed a technique for the generation of optical vector beams. Vector beams are pure modes of light with spatially dependent polarizations. Our technique utilizes a spatial-light modulator (SLM). The SLM is a high-definition liquid crystal display that was programmed with a diffraction pattern in order to produce two Laguerre-Gauss or Hermite-Gauss beams. By varying the relative phase between these two beams, the vector beam can be shifted from radial to azimuthal polarization. The process was demonstrated by the producing a radially polarized Laguerre-Gauss mode vector beam.

### Creating more Qubits with Spatial Mode Entanglement

Matthew Novenstern and Enrique J. Galvez
Colgate University

One of the biggest problems in quantum computing is the lack of qubits. Modern binary computers operate on trillions of bytes every second, and while it's easy enough to create a single pair of entangled photons through spontaneous parametric down-conversion, it is very inefficient to create more entangled photons after that. These photons are entangled in their polarization. We propose to transfer the polarization entanglement to entanglement of Hermite-Gauss modes. By creating this mode entanglement, we hope to enlarge the Hilbert space of the system, eventually having four qubits and bringing certain quantum algorithms within the reach of optical quantum computation.

### Search for an Entanglement Measure for N-Qubit States via Phase Symmetry

Joshua S. Geller
University of Rochester

While quantitative measures of entanglement exist for two-qubit systems, there are no equivalent measures for larger systems. Phase patterns within multi-qubit density matrices could yield clues to construct quantitative measures for these larger systems. One such pattern within the N-qubit density matrix is observed by reordering the matrix according to the types of coherence terms in the first row and first column so that the number of phases in each element increases from left to right in the first row, and from top to bottom in the first column. The resulting matrix contains blocks on its diagonal with elements having only bipartite entanglement. All remaining diagonal elements are part of GHZ-type states in this configuration. A benefit to this matrix structuring is the ability to apply concurrence, a measure of two-qubit entanglement, to the sub-matrix blocks formed on the diagonal. Exploring the meaning of these concurrences with regard to the entanglement of the whole system of N-qubits represented by the full density matrix is a possible next step toward finding a measure of N-qubit entanglement.

**Laser Induced Florescence Measurement of Ion Temperatures of Interacting Magnetic Flux Ropes in Argon Plasma**

Corey Adams[1], Prof Walter Gekelman[2], and Dr. Bart van Compernolle[2]
(1) University of Rochester, (2) University of California - Los Angeles

A useful plasma diagnostic tool is the method of laser-induced florescence. Using this technique, several important parameters of the plasma can be deduced, such as temperature and flow fields. This experiment used a precision controlled laser to excite argon ions from metastable excited states, which produced florescence in the visible range. The dynamic system observed was that of three interacting magnetic flux ropes in the Large Plasma Device (LaPD) located at the University of California, Los Angeles. Results of the experiment showed ion temperatures in the tens of thousands of Kelvin with rapidly occurring temperature diffusion.

## SESSION II. POSTER SESSION

### Improved design for a multibeam femtosecond Yb:KGW oscillator

Virginia Albany, Robert Grimming, and Kraig Sheetz
U.S. Military Academy at West Point

Presentation of an improved design for an Yb:KGW oscillator that generates four beams of temporally delayed, 250-femtosecond pulses. This design provides for easier optimization and improved ability to manage the output beams.

### Analysis of GALFACTS Data for the Study of Variable Radio Sources

Scott Barenfeld[1], T. Ghosh[2], and C. Salter[2]
(1) NAIC/University of Rochester, (2) NAIC

The G-ALFA Continuum Transit Survey (GALFACTS) is a spectro-polarimetric survey of Arecibo Observatory's visible sky from 1225-1525 MHz, using the Arecibo L-band Feed Array (ALFA). Among the survey's many scientific goals is a large-scale statistical study on the short-term variability of the flux density and polarization of radio sources. Every point in the sky is observed twice, with less than a month between observations, making this the largest systematic search for variability ever conducted. In this poster, we present the development of computer code to aid in this search, and some preliminary results obtained with this code. The code takes GALFACTS data in the form of time series for 2048 individual spectral channels, containing positions and full-stokes antenna temperatures, and turns these into a list of individual radio sources with their positions and Stokes-I temperatures. As a test, we first ran the code for the field surrounding the radio source S0206+330, which has a known flux density. Once we were satisfied that our code was working, it was run on the field of another radio source, S0311+307.

### Monitoring of spectral emissions using the Compact Spectrometer Array diagnostic on NSTX

Timothy DeHaas, Adam McLean
University of Rochester, PPPL, ORNL

An array of four high-speed (integration time 1 ms or more), medium resolution (2048 pixel CCD, 0.10 nm/pixel dispersion, 0.43 nm optical resolution), broadband (370-590 nm optical coverage), miniature (0.1 m focal length, f/4 symmetrical crossed Czerny-Turner design) spectrometers have been installed on NSTX as part of a new diagnostic tool called the Compact Spectrometer Array (CSA). A C++-based program was developed to operate multiple spectrometers simultaneously in concert with the NSTX discharge clock, and automatically upload data into the MDSplus database. This diagnostic tool complements existing high-resolution spectrometers on NSTX in spectral coverage and speed. These spectrometers are essential tools in understanding how the plasma interacts with the walls of the NSTX fusion device. Analysis of spectra from the

CSA, viewing the divertor targets for a variety of plasma configurations, are presented along with our interpretation of the corresponding particle flux and erosion characteristics obtained using measured discharge parameters and available atomic databases.

**The NIFFTE TPC Gas Handling System**

Nicholas Fuller and Dana Duke
Houghton College and California Polytechnic State University

The Neutron Induced Fission Fragment Tracking Experiment (NIFFTE) uses a Time Projection Chamber (TPC) to obtain accurate measurements of the fission cross sections of radioactive isotopes. Past cross-section measurements have used various detection methods, such as a parallel-plate ionization chamber, but by using a TPC the accuracy of the measured cross sections can be improved to better than 1%. Analysis of TPC data will improve the current understanding of fission dynamics and the fission process. The NIFFTE TPC is located at the 90L beam line at LANSCE-WNR, where targets are bombarded with fast neutrons to induce fission. The resulting fission fragments are tracked using gas ionization within the TPC. The functionality of the gas-handling system of the TPC and its assembly are discussed.

**Design and Implementation of a Timing Control System for use in a Bose-Einstein Condensate (BEC) Experiment**

Daniel N. Gresh and Nicholas P. Bigelow
University of Rochester

A high-precision timing system is required not only to create a BEC, but also to perform experiments on it and control steady-state operations in the lab. I designed and implemented the hardware interface and timing algorithms with microsecond precision of up to 100 digital and analog channels.
Supported by NSF PHY-0851243 and ARO.

**Deuteron Formation for Big Bang Nucleosynthesis Models**

Katrina Koehler and Prof. Mark Yuly
Houghton College

Cross sections for the H(n, dγ) reaction are being measured for incident neutron energies between 100 keV and 1 MeV at the Los Alamos Neutron Science Center by a collaboration of researchers from Houghton College, MIT, the University of Kentucky, and Los Alamos National Laboratory. This deuteron formation experiment is key to improving calculations of the baryon density in Big Bang Nucleosynthesis models. The deuterons are created and detected in a plastic scintillator active target. Gamma rays released by the neutron-proton capture reaction are detected in a BrilLanCe detector. Scattered neutrons from n-p elastic scattering, detected in two neutron detectors, are used to calibrate the active target ADC spectrum.

**Localization of a Hole on an Adenine-Thymine Radical Cation in B-Form DNA in Water**

S. M. Kravec, C. D. Kinz-Thompson, and E. M. Conwell
University of Rochester

Quantum/molecular-mechanics (QM/MM) molecular dynamics (MD) simulations have been carried out using CP2K for a hole introduced into a B-form DNA molecule consisting of 10 adenine-thymine (A/T) pairs in water. At the beginning of the simulation, the hole wavefunction is extended over several adenines. Within 20 to 25 fs, the hole wavefunction contracts so that it is localized on a single A. At 300 K, it stays on this A for the length of the simulation (several hundred fs) with little change in the wavefunction. At temperatures below 300 K, proton transfer from A to T is seen to take place within the A/T occupied by the hole; it is completed in about 40 fs after the contraction. We show that the contraction is due to polarization of the water by the hole. This polarization also plays a role in the proton transfer. Implications for transport are considered.

**The Design and Construction of a Deposition Chamber and Laser Interferometer for the Study of Thin Metal Films**

Tyler Reynolds, Joshua Mertzlufft, and Prof. Brandon Hoffman
Houghton College

A deposition chamber and a laser interferometer are currently under development at Houghton College. The deposition chamber produces and heats thin metal films under high vacuum. In order to measure curvature of the films as they are heated, the laser interferometer generates a topographical map of each film using a three-inch collimated beam of light and several optics components. The chamber and interferometer work in conjunction with one another, allowing for the films to be measured without breaking the vacuum. Using the relationship between curvature and temperature, the stresses of the films can be calculated.

**Accretion Processes in Class 0/I Protostars**

P.D. Sheehan, P. Manoj, and D.M. Watson
University of Rochester

We present our detection of a collection of $H_2O$ emission lines in the near-infrared Spitzer IRS high-resolution spectra of the Young Stellar Objects IRAS 13036 and MMS 6 North. Our modeling of the $H_2O$ emission lines indicates that these lines originate in a shock as material from the envelope arrives supersonically at the disk. From our model and the spectra we derive the accretion flow rates in the systems, and find that there is a large imbalance in the rate at which material is accreting onto the disk compared to the rate at which it is accreting onto the central protostar. We also find little to no evidence of an outflow associated with MMS 6 North, in agreement with the findings of other studies of MMS 6 North. Our derived flow rates provide evidence that material is being

amassed in the accretion disk and may be released onto the central star in an event similar to an FU Ori outburst, and thus supports the paradigm of episodic accretion.

**Atomic Layer Deposition of $TiO_2$ Thin Films**

Stephanie Swartz[1], Kasey Phillips[2], Jon Bradley[2], Mac Hathaway[3], and Eric Mazur[2]
(1) University of Rochester, (2) School of Engineering and Applied Sciences, Harvard University, (3) Center for Nanoscale Systems, Harvard University

If an optical switch can be made using a waveguide, we will be one step closer to creating an optical computer. Titanium dioxide ($TiO_2$) has optical properties that make it a good material to use in a waveguide. We chose Atomic Layer Deposition (ALD) as our method for creating $TiO_2$ thin films because it has the potential to create uniform and low-loss films. To do $TiO_2$ ALD, we developed a recipe for the films to use on our specific machine. Though our films do not yet guide light, they are anatase and they are very close to our ~200 nm thickness goal.

## SESSION IIIA. ASTRONOMY II

### The development of phototmetry/extinction/database modules for the Chimera Robotic Telescope System

J. Brown, J. Neeley, B. Gilfus, P. Thompson, P. da Silva. A. Kanaan, and S. Kanbur
University of Rochester, SUNY Oswego, and the Federal University of Santa Catarina, Brazil

We discuss photometry/extinction/database modules for the Chimera Robotic Telescope Control System. This is an easy-to-use, highly modular Robotic Telescope Control System written in Python. We also present some preliminary results of extinction coefficients taken at the Laborotorio Nacional Astrofisica, Brazil, in summer 2011.

### Calibration routines for the Chimera Robotic Telescope Control System

D. Quill, J. Primrose, J. Brown, P. da Silva, A. Kanaan, and S. Kanbur
SUNY Oswego, University of Rochester, and the Federal University of Santa Catarina, Brazil

We present data-reduction and photometry-calibration routines for the Chimera Robotic Telescope Control System. These routines automatically take zeros, darks, and flats for a night of automated observing. We demonstrate these routines with a sample of images taken robotically in summer 2010.

### Sample Images from the Chimera Robotic Telescope Control System: summer 2010,

J. Primrose, D. Quill, J. Brown, P. da Silva, A. Kanaan, and S. Kanbur
SUNY Oswego, University of Rochester ,and the Federal University of Santa Catarina, Brazil

We present a range of images taken entirely robotically with the Chimera Robotic Telescope Control System during summer 2010. The images taken were mainly of Galactic Open clusters containing Cepheids and demonstrate the viability of Chimera.

## SESSION IIIB. BIOLOGICAL/MEDICAL PHYSICS

### Biomineral Structure and Strength of Barnacle Exoskeletons

Nathan Swift and Prof. Rebecca Metzler
Colgate University

The process of building organic-inorganic compound structures through biomineralization is extremely impressive and potentially very useful. During biomineral formation, organisms restructure simple, naturally-occurring minerals in conjunction with their own organically produced minerals to create new structures, the functions of which often include protection or storage, among others. While there is extensive knowledge about materials properties and structure of the raw minerals themselves, insight into how specific biomineral structures and compounds contribute to an object's mechanical properties is lacking. In this study, the exoskeletons of several barnacles from the genus Balanus were examined thoroughly, both for their physical structure (how they are put together) and for their mechanical properties (tensile strength, hardness, and elasticity). Barnacles were chosen because of their abundance in salt-water environments; their early appearance in the fossil record; and their impact on the early studies of evolution. Scanning electron microscopy produced close-up, detailed images of the inner shell structure to determine what type of structure barnacles build during exoskeleton formation. In addition, energy dispersive x-ray spectroscopy was used to map the elemental components of the shells. Nanoindentation and microindentation tested the mechanical properties of these mapped structures to determine how certain characteristics of the exoskeleton contribute to its hardness, strength, and elasticity.

### The Effect of Ultraviolet Sunlight on the Survival of e.Coli: Disassembling Existent Biofilms

Rachel Nelson and Dr. Thomas Coohill
Siena College

The purpose of this experiment was to quantitatively predict the solar sensitivity of vegetative bacterial cells exposed to UVC (254 nm) radiation, upon successfully isolating single bacterial colonies through degradation of biofilms. A spectrum, illustrating the solar effectiveness for inactivation of vegetative cells, was constructed by combining the available action spectra for vegetative cell death in the solar range with the natural sunlight spectrum that reaches the ground. Previous studies were analyzed to assist in the generation of a survival curve from experimental decay data. Although UVC-sensitive cells were more sensitive to solar radiation, no absolute numerical correlation was established between the relative solar sensitivity of vegetative cells and their sensitivity to 254 nm radiation. The estimate presented in this experiment, based upon the survival curve, should facilitate prediction of the time required for natural solar UV to kill bacterial spores. This study has a direct application to the advancement of biological warfare, in that the estimations can be applied to vegetative bacterial cells after dispersion from an infected host or after an accidental or intentional release. The genetic formation

of biofilms alters the shape of the survival curve, such that individual cells are shielded from radiation by aggregates of other cells.

**Cell Classification based on Artificial Neural Networks**

James Crawford and Dr. Theodore von Hippel
Siena College

The idea of my project is to develop a working Artificial Neural Network (ANN) to differentiate and classify specific abnormal (cancerous) cells from normal cells. Further, automate this process to work as a pathology decision-making algorithm, thus providing quick identification and diagnosis. This is done by extracting parameters from microscopic images of various tissues, like lung, breast, and prostate tissues, to obtain data of normal and abnormal cells. The data is run through the network-learning phase so that the ANN eventually recognizes patterns to identify the different cell types. The ultimate goal is to automate the entire process and get quality results. This network could have major benefits in the medical field where it can provide faster cell identification, resulting in quicker patient diagnosis, as well as a reduction of the number of false negatives and positives, which is very important in oncology. It can decrease the costs associated with medical tests and procedures. A well-trained network could provide an even better, more consistent, diagnosis and the results are not affected by human errors.

**MR Spectroscopic Imaging with MIDAS and Matlab**

Daniel deLahunta and Jacob Mathews
University of Rochester

MR spectroscopic imaging (MRSI) is a method used to image the concentrations of different metabolites in the human body. The MRI that everyone usually thinks about measures just the signal coming from the protons in the water molecules in the tissue. MRSI measures the signals coming from the protons in many of the other metabolites present in the tissue. The difference is that the water signal is much larger than that of the other metabolites. As a result, the signal-to-noise ratio (SNR) is much lower in MRSI and the metabolite images are of lesser quality than the water images. Valuable information can still be obtained from these images however. We used a software package (MIDAS) and imaging sequence developed at University of Miami to process data that was taken at the University of Rochester using the imaging sequence. We then developed a program in Matlab that displays the image information in a suitable manner.

## SESSION IVA. CONDENSED MATTER PHYSICS

### Anomalous diffusion of random walkers on a disordered lattice with quenched persistence

Steven Bandes and Professor Yonathan Shapir
University of Rochester

We investigated the effects of persistence on the diffusion properties of random walks with several types of disorder. We first considered the problem of simple persistence that contains no disorder. We also consider the problem of annealed persistence in which each step taken by the walker is assigned some random probability to persist. The last case we consider is the case of quenched persistence in which the probability of persisting is randomly assigned for each lattice site. As a final generalization we consider the asymmetric case, in which each lattice site has a different probability of persisting, depending on which direction it was approached from. A range of methods are applied, including the evaluation of characteristic functions and direct measures of variance. For the quenched cases, calculations of the mean first-passage time (MFPT) were used. Regular diffusion occurs for all but the quenched case with asymmetric persistence probabilities that show anomalous results similar to that of the random force model.

### Controlling the Sample Temperature in a Vacuum Thin Film Deposition Chamber

Adam Silvernail and Prof. Brandon Hoffman
Houghton College

A thin-film sample heater is being constructed for the Houghton College deposition chamber. Samples will be heated in vacuum to measure thin film curvature as a function of temperature for various metals, such as silver and titanium. A ceramic mount holds the tungsten element heater and sample holder to the roof of the chamber so that the sample can rotate for uniform heating. A potential difference between the sample and the tungsten element is used to accelerate electrons to the sample, increasing the thermal energy of the sample. Molybdenum shielding encloses the heater apparatus to promote uniform heating of the sample and provide thermal isolation from the chamber apparatus. Testing of this system is expected to begin this summer.

### Indium Thin Film XRD Characterization and Electrical Analysis

Andrew Gaul, Dr. H. Trevor Johnson-Steigelman, and Dr. Mohammed Tahar
The College at Brockport

Using vacuum vapor deposition, In films were grown on $SiO_2$ and In substrates. Growth-rate control methods were established, allowing for film thicknesses in range of 150 - 1100 nm, which were determined using X-ray transmission. X-ray diffraction (XRD) was performed on the films, and the data was analyzed using Fityk. Analysis of the first three

families of [Kα1 and Kα2] x-ray doublets revealed the films' micro-crystal sizes and showed a trend of In atoms preferring to align in the 101 (hkl) plane with increasing film thickness. Low-temperature resistivity measurements were performed on an In/$SiO_2$ film, and using this data, XRD data, and the Fermi parameters for In, it was discovered that the vacuum vapor deposition of In causes the film crystallites to grow ~10x faster perpendicular to the film than parallel to the film. Conductance and differential conductance measurements performed on an In/In/$SiO_2$ film showed the electrical behavior of the In/In junction to be ohmic at room temperature, indicating a lack of oxide(s) between the film layers.

**The Kondo Problem: A Toy Model for Renormalization**

Gregory Bentsen and Sarada Rajeev
University of Rochester

We study the renormalization of the Kondo and Anderson models in condensed-matter physics. These models describe the interaction of a spin impurity (such as Fe) imbedded in a conducting host metal (such as Ag). Unfortunately, if not treated carefully, these models lead to divergent quantities. Renormalization must be used to render the models finite. Due to the half-filled valence shell of the impurity atom, a magnetic dipole moment is formed, from which conduction-band electrons scatter. At high temperatures these dipole moments are oriented randomly, and so their net effect on the conduction electrons is negligible. At very low temperatures, however, these moments tend to align or anti-align, and electron scattering becomes significant; as a result, the resistance of the metal increases. Experiments have shown that for low temperature $T$ this resistance goes as $\log(T)$, but at $T \rightarrow 0$ the resistance tends to a finite value. Treated in perturbation theory, the Kondo model gives this $\log(T)$ dependence, but predicts infinite resistance at $T = 0$, which is non-physical and is in disagreement with experiment. Mean-field theory may be used to treat this model non-perturbatively, but divergent quantities still appear. Under an appropriate renormalization scheme, however, the model is finite and may be interpreted as a Landau liquid of heavy fermions. The renormalized model also correctly predicts finite resistance at $T = 0$, as expected. Similar calculations have also been applied to the related Anderson model. No conclusive results have been established for this model, although several clues appear in calculations. Among these, we expect that the average occupation of the impurity be precisely equal to unity in the limit of large Coulomb repulsion $U$. Calculations also seem to suggest that a renormalized theory must have the hybridization coefficient $V_k$ go as $U / \log(U)$ in the limit of large Coulomb repulsion.

This work was supported by the summer 2010 Research Experience for Undergraduates (REU) Program at the University of Rochester and by the National Science Foundation.

**Water Desorption from Various Ferroelectric and Dipole Oriented Polymers**

Mark Stewart, Michael Evans, Lillie Ghobrial, Gregory Maslak, Luis Rosa, Peter Dowben, and Carolina Ilie
SUNY Oswego

Herein we compare the water absorption / adsorption on three different polymer films: the ferroelectric co-polymer poly (vinylidene fluoride with trifluoroethylene) P(VDF-TrFE), the strongly dipole oriented polymer poly (methyl vinylidene cyanide) (PMVC) [1], and the dipole oriented poly (methyl methacrylate) (PMMA). We investigate the dipole-dipole interaction of the water molecule and the ferroelectric / dipole oriented polymer films and we propose that the dipole interactions may affect the surface chemistry at these polymer surfaces. Surface dipoles can affect the binding site of water species adsorbed at the surface and sterically hinder or enhance desorption of adsorbed and absorbed water.

[1] Dowben, P.A., Rosa, Luis G., Ilie, C.C., *Zeitschrift für Physikalische Chemie* 222 (2008) 755-778.

## SESSION IVB. NUCLEAR AND PARTICLE PHYSICS

### Design and Construction of a Compact 2 MeV Proton Cyclotron – "The Cyclotron Kids"

Peter Heuer
Thomas Jefferson National Accelerator Facility

The purpose of this project was to develop a small (12 inch diameter and ~ 2 MeV) cyclotron for educational and research applications. At this time, the cyclotron is nearly assembled and first beam is expected to occur during the summer of 2011. This talk will summarize the design of the accelerator, discuss some of the challenges faced in designing such a compact accelerator, discuss the current state of the project, and make the case for student-directed projects as an educational tool.

### Designing an algorithm for a three-dimensional Hough transform of the reconstruction of low-energy events

Dilyana Mihaylova and Prof Kevin McFarland
University of Rochester

We designed an algorithm for a three-dimensional Hough transform for the tracking of low-energy events from the Minerva detector. The tracking system currently used does not allow for the tracking of linear low-energy events due to the fact that the two-dimensional Hough transform can only do a linear search for one view at a time. A three-dimensional Hough transform allows for combining the hits from all three views of the Minerva detector, thus allowing track reconstruction of shorter events that would otherwise be missed.

### Particle Detector Design Using Delay Line Technique to Determine Anode Position

Robert Carroll and Dr. Allan Weatherwax
Siena College

Past particle detector designs tend to rely heavily on electronics to determine anode position. This approach is difficult to implement on space missions that are limited by space, power, or cost. With a new particle detector design, known as the Delay Line Detector (DLD), much of the electronics used in other designs can be eliminated. The DLD will implement a novel technique which uses the time it takes for signals to propagate through series of delay lines to determine their origins on an anode. When a signal originates at a sector on the anode, it will split and propagate along two delay chains in opposite directions. These signals will recombine at varying points along a matching delay chain and trigger responses in a FPGA depending on which anode the signals originated from. This design is very flexible and can accommodate missions with as many anodes as needed and in unique shapes. Most importantly are the improvements the DLD can make in space, power and cost.

**Siena's Muon Detector**

Kristin Del Belso and Dr. John Cummings
Siena College

The purpose of this procedure is the creation of an apparatus that accurately determines the lifetime of a muon. Through the use of a scintillator, photomultiplier tube and CAMAC crate, connected to a computer program we are able to collect data over an extended period of time. This allows us to be able to graph the data and determine the average muon lifetime. This apparatus will be useful for future students in their attempts to understand more about particles such as muons and their lifetime.

**Neutron-Induced Deuteron Breakup**

Katrina Koehler and Prof. Mark Yuly
Houghton College

An experiment to measure the quasielastic d(n, np)n scattering cross-sections at intermediate incident neutron energies, ranging up to 800 MeV, was conducted by a collaboration of researchers from Houghton College, MIT, the University of Kentucky and Los Alamos National Laboratory at the Los Alamos Neutron Science Center (LANSCE). Scattered protons from deuteron breakup travel through a magnetic spectrometer, consisting of an initial thin plastic $\Delta E$ scintillator, a set of drift chambers, two permanent magnets, another set of drift chambers and two rear plastic scintillators. An array of nine two-meter high plastic scintillators detects scattered neutrons. The np elastic scattering data collected in tandem with this experiment is being analyzed to determine normalization for the cross-section for the n-d breakup reaction.

## SESSION IVC. EXPERIMENTAL TECHNIQUES

### A Mutual Inductance Bridge for Electric and Magnetic Measurments

Todd Rutkowski, Dr. M. Z. Tahar, Dr. E. Monier, and Dr. H. T. Johnson-Steigelman
The College at Brockport

A mutual inductance bridge system is developed and used to preform measurements on various metal samples. Starting with Maxwell Equations the system is modeled and further developed to extract the desired physical quantities from the various parameters of the experiment. Contactless conductivity measurements were made for copper and aluminum cylindrical samples with a reasonable agreement with the published data. Also, the frequency dependence of conductivity has been examined and is used to provide an estimate of the static conductivity. Further uses of the bridge are discussed and explored, such as use in electric and magnetic susceptibility measurements and for investigating phase transitions of magnetic and superconducting materials to determine transition temperatures and behavior with thermal cycling.

### Comparative Studies of electrical and mechanical Chaotic Systems

Ryan Held
The College at Brockport

Nonlinear systems like Chua's circuit and the damped driven pendulum have been extensively studied ever since chaos has been of interest. Chua's circuit is the first circuit to exhibit chaotic behavior, and consists of an oscillatory circuit with a nonlinear negative resistor. The pendulum is a copper torsion pendulum driven by an electric motor, and damped by a stationary magnet. In this project, the presenter explores both of these systems and some of their characteristics. Topics of exploration include period doubling route to chaos, Feigenbaum numbers, equilibrium point analysis, and comparison of data with models.

### Dynamics of a Plasma Gun

Colin Marcus
University of Rochester

This paper covers the ongoing development of a two-stage plasma gun, which uses a combination of pneumatic pressure and the Lorentz force to accelerate an aluminum projectile. The projectile is expected to be partially vaporized to a plasma state, resulting in a combination of plasma, liquid, and solid metal.
The project has not yet physically reached the experimental stage, so I will discuss its design and the physics involved in its operation. In particular, I will attempt to predict the muzzle velocity, which will be the main measurable variable when the experiment is actually carried out.

**Using a Star to See Stars**

Andrew Whyte and Dr. Allan Weatherwax
Siena College

Renewable energy has been around for a few decades. It has many benefits including it saves money, better for the environment, and, if done correctly, it can eliminate the need for traditional sources of electricity. I am using renewable energy to power telescopes on campus. These telescopes use 308 watts per hour (this includes power for a CCD camera, laptop, heat sources in the winter, and telescopes), so it's obvious why renewable energy is a good option. To solve this problem of bringing power to the telescopes, I am building a solar powered generator that will allow them to run at night. This generator will have a circuit and a battery with solar panels attached to them. After attaching the generator to the telescopes they will be running completely on renewable energy. This will help Siena in the long run because they won't have to worry about powering the telescopes anymore. A large-scale model of this system is also being created to power the homes of families in other countries, such as Haiti, so as to help them have both electricity and a renewable source of energy.

**Room Acoustics - Measurement and Analysis**

Paul Bauch
The College at Brockport

A preliminary investigation of room acoustics comparing experimental and theoretical results identified a possible method to measure room reverberation. Initial theoretical results, determined by Sabine's formula, showed a reverberation time (the time a sound intensity takes to decrease 60 db) of 1.1 s at 1000 Hz, a mid-range frequency for human speech. Analysis of the reverberation time was measured using MATlab programming and LabVIEW data collection. An acoustically "bad" room, selected based on poor speaking clarity due to high reverberation, was analyzed by measuring voltage outputs of an omni-directional microphone through an RMS peak signal processor. This process was done repeatedly in order to sample specific sound frequencies that were introduced into the room through a loud speaker. Experimental data shows the decay of sound energy over time that was compared to Sabine's formula.

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