XXXI

Annual

Rochester Symposium For Physics (Astronomy & Optics) Students
SPS Zone 2 Regional Meeting held at Siena College

April 14, 2012

Department of Physics and Astronomy
University of Rochester
Rochester, NY 14627-0171

Cosponsored by:
National Office of the Society of Physics Students; Department of Physics and Astronomy, Siena College; Department of Physics and Astronomy, University of Rochester; National Science Foundation (REU Program); Department of Energy

Rochester, April 14, 2012

Dear Participants:

Welcome to the 31st 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/RSPS2012.

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
Alarie, Alicia	10:15 AM	LOBBY
Barenfeld, Scott	10:15 AM	LOBBY
Beyer, Jacob	8:45 AM	RB 202
Birrittella, Richard	1:45 PM	RB 238
Breindel, Alexander	8:45 AM	RB 226
Carranza, Raul	2:00 PM	RB 238
Degner, Brian	11:00 AM	RB 202
Dunn, Alex	2:45 PM	RB 238
Evans, Andrew	10:15 AM	LOBBY
Farbman, Karen	10:15 AM	LOBBY
Fuller, Nicholas	10:15 AM	LOBBY
Gardner, John	1:45 PM	RB 226
Gilchrest, Ian	11:00 AM	RB 238
Grossman, Kevin	1:45 PM	RB 202
Gura, Anna	10:15 AM	LOBBY
Hasan, Imran	10:15 AM	LOBBY
Kinney, Stephanie	2:00 PM	RB 226
Knupp, Chris	11:00 AM	RB 226
Kroening, Peter	11:15 AM	RB 238

NAME	TIME	LOCATION
Kuhl, Alexandria	11:30 AM	RB 238
Lankevich, Vladimir	9:00 AM	RB 226
Larkin, LeighAnn	11:15 AM	RB 202
Lasker, Eric	9:15 AM	RB 226
Lauer, Colin	10:15 AM	LOBBY
Levine, Nathan	2:00 PM	RB 202
Lin, Bin	10:15 AM	LOBBY
Long, Kaho	9:30 AM	RB 226
Mann, Keith	10:15 AM	LOBBY
McCaskill, Jesse	10:15 AM	LOBBY
McKinley, Robert	9:00 AM	RB 202
McLeod, Jordan	11:15 AM	RB 226
Mikler, Ana	9:15 AM	RB 202
Miller, Maximilian	9:45 AM	RB 226
Mullarkey, Christopher	2:15 PM	RB 238
O'Malley, Erin	9:30 AM	RB 202
Ocock, Ethan	10:15 AM	LOBBY
Pater, James	11:30 AM	RB 226
Schubert, William	2:30 PM	RB 238

NAME	TIME	LOCATION
Schultz, Charles	2:15 PM	RB 226
Sise, Anna	11:45 AM	RB 226
Slye, Jonathan	11:45 AM	RB 238
Spencer, Mark	10:15 AM	LOBBY
Turck, Kyle	11:45 AM	RB 202
VanKerkhove, Jeffrey	9:45 AM	RB 202
Viani, Lucas	10:15 AM	LOBBY
Yu, Vincent	2:15 PM	RB 202
Zimmerman, Robert	2:30 PM	RB 226
Zranchev, Amanda	10:00 AM	RB 226

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

PROGRAM

8:00 AM – 8:30 AM: REGISTRATION AND POSTER SETUP (RB LOBBY)

8:30 AM: WELCOME (RB 202)

Prof. Frank Wolfs, University of Rochester.
Prof. Allan Weatherwax, Dean of Science, Siena College.

8:45 AM – 10:00 AM: SESSION IA. ASTRONOMY I (RB 202)

SESSION CHAIR: PROF. DALE ZYCH (SUNY OSWEGO)

8:45 Intergalactic MgII Absorbers in the Sloan Digital Sky Survey
Jacob Beyer, SUNY Brockport

9:00 Magnetic Properties of the Imilac Pallasite
Robert McKinley, University of Rochester

9:15 Rr Lyrae Stars In The Globular Star Cluster Ic 4499
Ana Mikler, Union College

9:30 Deriving the Ages of the Oldest White Dwarfs: A Bayesian Analysis
Erin O'Malley, Siena College

9:45 The Evolving Disks of T Tauri Stars
Jeffrey VanKerkhove, University of Rochester

8:45 AM – 10:15 AM: SESSION IB. BIOPHYSICS (RB 226)

SESSION CHAIR: PROF. STANLEY RADFORD (SUNY BROCKPORT)

8:45 Hole Transport in DNA
Alex Breindel, University of Rochester

9:00 New Simplified Model Designed to Investigate Anisotropic Coulomb Interactions between Charged Proteins: Validation by Comparison of the Electrostatic Potentials
Vladimir Lankevich, University of Rochester

9:15 Efficiency of Synchronization of Entorhinal Cortex Layer II Stellate Cells
Eric Lasker, Colgate University

9:30 pH Dependence of Bovine γB Crystallin Virial Coefficient
Kaho Long, Rochester Institute of Technology

9:45 Adding coupling to the Josephson junction neuron model
Maximilian Miller, Colgate University

10:00 Characterizing Lake Tanganyika Shell Damage Using Micro-Indentations
Amanda Zranchev, Colgate University

10:15 AM – 11:00 AM: SESSION II. POSTER SESSION (LOBBY RB)

Real Time-3D Sound Spatialization
Alicia Alarie, University of Rochester

The AB Dor Moving Group: A Chemically Heterogeneous Kinematic Stream?
Scott A. Barenfeld, University of Rochester

A Possible $^{12}C(n,2n)^{11}C$ Total Cross Section Measurement
Andrew Evans and Keith Mann, Houghton College

Visualizing the Flute Air Jet
Karen Farbman, University of Rochester

Characterizing the Houghton College Cyclotron
Nicholas Fuller, Houghton College

Coherent Beam Stimulated Parametric Down Conversion in Quantum Interferometry
Anna Gura, Lehman College

Capture of Irregular Sattelites Via Binary Planetesimal Exchange Reactions In Migrating Planetary Systems
Imran Hasan, University of Rochester

Simulating Coulomb Interacting Dark Matter
Colin Lauer, Houghton College

Jets or Clumps in CRL 618
Bin Lin, University of Rochester

Searching for Non-Locality in Two-Mode "Arcsine" States and their Superpositions
Jesse McCaskill, Lehman College

Design and Construction of a Variable Temperature Atomic Force Microscope
Ethan Ocock, Houghton College

The Houghton College Scanning Transmission Electron Microscope
Mark Spencer, Houghton College

Star Formation in the NGC 5846 Group of Galaxies
Lucas Viani, Union College

11:00 AM – 11:45 AM: SESSION IIIA. HIGH-ENERGY AND NUCLEAR PHYSICS (RB 202)

SESSION CHAIR: PROF. JOHN CUMMINGS, SIENA COLLEGE

11:00 Optimizing Efficiency of the LUX Trigger System
Brian Degner, University of Rochester

11:15 Spin-dependent Forces in Heavy Quarkonia
LeighAnn Larkin, SUNY Brockport

11:30 Resistuino: An ultra pure water-monitoring device for the Daya Bay Core Neutrino Experiment
Kyle Turck, Siena College

11:00 AM – 12:00 PM: SESSION IIIB. CONDENSED MATTER PHYSICS (RB 226)

SESSION CHAIR: PROF. MOHAMMED TAHAR, SUNY BROCKPORT

11:00 Method for Building a Mutual Inductance Bridge for the Purpose Measuring Magnetic Susceptibilities
Chris Knupp, SUNY Brockport

11:15 Experimental Investigation of Silicon Powders using X-Ray Diffraction
Jordan Metz McLeod, SUNY Brockport

11:30 The Orientation Dependence of NBTI Degradation in pMOS FinFETs
James Pater, Siena College

11:45 Production and Characterization of Electrospun Nanofibers
Anna Sise, Union College

11:00 AM – 12:00 PM: SESSION IIIC. EXPERIMENTAL TECHNIQUES (RB 238)

SESSION CHAIR: PROF. MARK YULY (HOUGHTON COLLEGE)

11:00 Delay Line Detection
Ian Gilchrest, Siena College

11:15 Reducing Dose While Maintaining Image Quality for Cone Beam Computed Tomography
Peter Kroening, Houghton College

11:30 Physical Concepts of Ground Penetrating Radar
Alexandria Kuhl, SUNY Brockport

11:45 Multi-plate Chamber Construction and Operation
Jonathan Slye, Houghton College

12:00 PM: LUNCH (WEST ROOM, SIENA DINING FACILITY)

12:45 PM: "NEUTRINO PHYSICS EXPERIMENTS: IT'S BEEN AN EXCITING YEAR!", PROF. J. NAPOLITANO, RENSSELAER POLYTECHNIC INSTITUTE (RB 202)

1:45 PM – 2:30 PM: SESSION IVA. ASTRONOMY II (RB 202)

SESSION CHAIR: PROF. BRANDON HOFFMAN (HOUGHTON COLLEGE)

1:45 Photometric Capabilities of the SUNY Brockport Observatory
Kevin Grossman, SUNY Brockport

2:00 Classifying Planetary Spectra and the Search for an Earth Analog Using Artificial Neural Networks
Nathan Levine, Siena College

2:15 Herschel spectroscopy of protostars in Orion: Far-infrared CO emissions
Vincent Yu, University of Rochester

1:45 PM – 2:45 PM: SESSION IVB. EXPERIMENTAL AND TEACHING TECHNIQUES (RB 226)

SESSION CHAIR: PROF. CHRISTOPHER WELLS (HOUGHTON COLLEGE)

1:45 The Monochromator
John Gardner, SUNY Brockport

2:00 Finding Connections: Regents vs AP in the College Classroom
Stephanie Kinney, Siena College

2:15 Analysis of bifurcation trends in population models approaching chaos
Charles Schultz, United States Military Academy

2:30 A Review of Independent Component Analysis
Robert Zimmerman, Siena College

1:45 PM – 3:00 PM: SESSION IVC. QUANTUM OPTICS (RB 238)

SESSION CHAIR: PROF. MARK ROSENBERRY (SIENA COLLEGE)

1:45 Pair-Coherent States and Quantum Optical Interferometry
Richard Birrittella, Lehman College

2:00 Quantum Optical Interferometry with Photon-Subtracted Two-Mode Squeezed Vacuum States
Raul Carranza, Lehman College

2:15 Quantum Random Walks in Photonic Waveguide Lattices
Christopher Mullarkey, Rochester Institute of Technology

2:30 Generating a Four Qubit Linear Cluster State
William Schubert, Colgate University

2:45 Quantum Properties of Light
Alex Dunn, Rochester Institute of Technology

SESSION IA. ASTRONOMY I

INTERGALACTIC MGII ABSORBERS IN THE SLOAN DIGITAL SKY SURVEY

Jacob Beyer and Eric Monier
SUNY Brockport

Absorption lines observed in quasar spectra allow us to study the evolution of gas and galaxies in a way that is independent of imaging techniques. In this submission, I describe my work on a catalog of absorption lines due to singly ionized magnesium (MgII) atoms, seen in quasar spectra. Magnesium is produced during nucleosynthesis in massive stars, and enriches the gas of a galaxy when it is ejected in supernova explosions. MgII is an indicator of low-ionization and neutral gas, and is therefore an excellent tracer of galaxies. The goal of this project is to complete a catalog of all the MgII systems contained in the quasar spectra of the Sloan Digital Sky Survey. This year, ~3000 spectra have been found and searched, adding to the ~40,000 spectra searched during Summer 2010. Confirmed systems are measured to determine their positions and absorption strengths. Once the measurements are complete, I will compare the properties of the systems found here at Brockport with results of earlier work (based on prior SDSS releases) done at the University of Pittsburgh.

MAGNETIC PROPERTIES OF THE IMILAC PALLASITE

Robert McKinley, Dr. John Tarduno, and Dr. Rory Cottrell
University of Rochester

Pallasite meteorites are unique mixes of olivine [(Mg, Fe)2SiO_4] crystals in a matrix of Fe-Ni metal. This composition raises questions about their formation and the evolution of their parent body. We studied the magnetization of microscopic magnetic inclusions in the olivine of the Imilac Pallasite meteorite that may have preserved the magnetic field of the parent body. The single domain inclusions we are looking for have long relaxation times (on time scales of billions of years) and are ideal records of the potential dynamo of the Pallasite parent body. Using a Princeton Measurements Alternating Gradient Force Magnetometer (AGFM), potential single domain carriers in olivine fragments were identified and analyzed further with a Zeiss Supra 40VP Scanning Electron Microscope with EDAX (Energy Dispersive X-RAY Spectroscopy) to image potential single domain grains and determine their composition. SEM work on the new Imilac sample has only just begun and the search for single domain inclusions and EDAX analysis of their composition will continue through the coming year.

RR LYRAE STARS IN THE GLOBULAR STAR CLUSTER IC 4499

Ana Mikler, Andrea Kunder, and Francis Wilkin
Union College and Cerro Tololo Interamerican Observatory, Chile

Observations of the globular cluster IC4499 were taken with the 1-m telescope at Cerro Tololo. These observations were combined with archival data to study the variable star population with CCD photometry. Using U,B,V,R,I passbands, the magnitudes and pulsation period have been measured for all 97 RR Lyrae stars in the cluster. Using these periods, we have also constructed light curves in all passbands available. We also compared the obtained magnitudes of the RR Lyrae stars with those reported by Walker[1]. The distribution of stars on the horizontal branch is compared with estimates from theoretical models and used to determine color limits to the intersection of the instability strip and the horizontal branch.

[1] Walker, A., 1996, Astron. J 112, 2026

DERIVING THE AGES OF THE OLDEST WHITE DWARFS: A BAYESIAN ANALYSIS

Erin O'Malley, T. von Hippel, and R. Finn
Siena College and Embry-Riddle Aeronautical University

We present a Bayesian analysis of 130 SDSS cool white dwarfs with optical and infrared photometry, a subset of which also has trigonometric parallax measurements. Instead of a step-wise progression of fitting a temperature, mass, and age for each star (as is done in previous studies), we employ a Bayesian analysis to simultaneously and self-consistently fit model atmospheres, white dwarf evolutionary models, initial-final mass relation, and precursor main-sequence ages to derive posterior age distributions. We fully incorporate the non-linear aspects of all of these model ingredients in this analysis. The goal of our study is to mine the age information available in these and other cool white dwarfs in order to better understand the details of how the different models affect age determinations of white dwarfs.

THE EVOLVING DISKS OF T TAURI STARS

Jeffrey VanKerkhove
University of Rochester

We have collected data from the Spitzer Space Telescope mission, from which we have extracted spectra from approximately 80 young stellar objects in the Taurus-Auriga Dark clouds, about half of which have been observed over multiple epochs. Spectral plots have been produced to gauge the evolutionary stages of these stars. Two-Temperature Modeling has also been carried out to compute the dust composition of their accretion disks, which is then used to determine how concentrations have varied over the course of the Spitzer campaign. A case study of BP Tau has confirmed this star to be a typical T Tauri variable, that is a young, Class II object of low mass and large radius. Additionally, two-temperature analysis has shown that the inner region of the disk is comprised predominantly of small-grained and amorphous dust species while the outer disk region is generally large-grained and crystalline in composition. Observations of dust evolution over the course of the mission have shown increasing concentrations of large amorphous grains within the disk, likely indicating the growth of grains heterogeneous in composition via agglomeration.

SESSION IB. BIOPHYSICS

HOLE TRANSPORT IN DNA

Alexander Breindel
University of Rochester

Hole transport in DNA is important because a moving hole can affect the chemical behavior of the DNA. It also been recognized as having the potential to allow creation of very small biologically based electronic devices, but the rate of hole transport is too low for useful devices. Recent research has found, however, that replacing adenine with 7-deazaadenine increases the hole-hopping rate significantly. My research has been aimed at finding out why this rate increase occurs and what mechanisms determine the hopping rate in DNA. I worked on preparing a computer model of 7-deazaadenine to be used in simulations using the modified DNA. This involved creating not only the actual coordinates and bond information for the molecule, but also assigning charges to the atoms. The former was done using the AMBER suite of programs and the latter using a method known as Restrained Electrostatic Potential for charge derivation. The simulations the model is to be used in are to be carried out using a program called CP2K which models mixed quantum mechanics and molecular mechanics using Density Functional Theory

NEW SIMPLIFIED MODEL DESIGNED TO INVESTIGATE ANISOTROPIC COULOMB INTERACTIONS BETWEEN CHARGED PROTEINS: VALIDATION BY COMPARISON OF THE ELECTROSTATIC POTENTIALS

Ho Yin Chan, Vladimir Lankevich, Vassiliy Lubchenko, and Peter Vekilov
University of Houston and University of Rochester

Being part of Dr. Vassily Lubchenko's group at University of Houston, I have been participating in developing a computationally efficient method to evaluate the potential of mean force (PMF) between two folded protein molecules that allows for complete sampling of their mutual orientation. The present model accounts for the actual charge distribution on the surface of the molecules, the dielectric discontinuity at the protein-solvent interface, and the possibility of protonation or deprotonation of surface residues induced by the electric field due to the other protein molecule. More specifically, I have focused on the electrostatic aspect of the model, evaluating its predictions for the electrostatic potential using Adaptive Poisson Boltzmann Solver (APBS) software package. A highly probable two-protein configuration predicted by our model has been inputted into the APBS to determine the electrostatic potential on and around the protein molecules. The electrostatic potential determined by our model agrees very well with the results found using APBS. The model has been applied to the protein lysozyme, whose solutions exhibit both mesoscopic clusters of protein-rich liquid and liquid-liquid separation; the former requires that protein form complexes with typical lifetimes of the order msec. We find the electrostatic repulsion is typically lower than the prediction of the DLVO theory. The Coulomb interaction in the lowest-energy docking configuration is non-repulsive, despite the high positive charge on the molecules. Typical docking configurations barely involve protonation or deprotonation of surface residues. The obtained PMF between folded lysozyme molecules is consistent with the location of the liquid-liquid coexistence, but produces dimers that are too short-lived for clusters to exist, suggesting lysozyme undergoes conformational changes during cluster formation.

EFFICIENCY OF SYNCHRONIZATION OF ENTORHINAL CORTEX LAYER II STELLATE CELLS

Eric Lasker
Colgate University

It is generally accepted that synchrony in various regions of the mammalian central nervous system is important. The metabolic energy demands on a system that is attempting to synchronize stands as a gap in experimental data. Using realistic models of networks of entorhinal cortex layer II stellate cells, this study examines the dependence of energy consumption and synchronization time on various parameter ranges of network attributes including: network topologies, coupling strengths and homogeneity, noise and oscillation frequencies. Similar parameter sweeps were performed in order to create phase response curves for locations of interest. By looking at the problem of synchronization through these two lenses we hope to discover robust local extrema in our data in either or both energy and time demands of our system.

PH DEPENDENCE OF BOVINE γB CRYSTALLIN VIRIAL COEFFICIENT

Kaho Long
Rochester Institute of Technology

Recent work has shown that interactions between γ-crystallin proteins located in the eye can contribute to the formation of cataracts. Of the techniques available one of the most useful for measuring the interactions is the second virial coefficient, B2, where the virial coefficients quantify the low concentration deviations from ideal solution thermodynamics. To measure the virial coefficient of the γB-crystallin proteins static light scattering was used. From the light scattering measurements the value of the molecular weight was determined to be (22659±1220) (mean ± std. dev.) grams/mole, which does agrees within twice the standard deviation to the sequenced value of 20992.7 grams/mole for single γB-crystallin proteins. The dimensionless second virial coefficient, B2, at a pH of 4.4 was measured to be (8.11±0.99) which is greater than that predicted from the model of hard spheres and hard sphere dimers suggesting a more repulsive interaction as expected at this pH from prior work in this lab.

ADDING COUPLING TO THE JOSEPHSON JUNCTION NEURON MODEL

Maximilian Miller
Colgate University

We consider an analog model of a single neuron made of superconducting circuits utilizing Josephson Junctions. This model is unlike other current models because it is not a computer simulation, but rather a parallel analog model; because of this, it is orders of magnitude faster than computer models. However, it would be useful and realistic to extend this model to systems of several neurons, and eventually, a neural network analogous to a human brain. Using the known equations of motion, we are currently performing simulations of multiple coupled neurons, each with a long axon chain.

CHARACTERIZING LAKE TANGANYIKA SHELL DAMAGE USING MICRO-INDENTATIONS

Amanda Zranchev
Colgate University

Biominerals and the process by which they form, biomineralization, are naturally occurring mysteries that we have much to learn about. Through the study of the biomineral calcium carbonate in snail shells, we learn about the mechanical properties of biominerals and whether and how different modes of damage affect shell hardness. We study the calcium carbonate aragonite found in the shells of freshwater Lake Tanganyikan snails. The species we examine, Lavigeria Nassa, exhibits extraordinary mechanical properties and lack the weakly calcified, thin, and brittle shells commonly associated with freshwater organisms. Instead, they closely resemble the shells of marine gastropods because of the co-evolutionary relationship they have with the crabs that prey on them. The shells of interest are comprised of between 1 - 5 cross-lamellar aragonite layers and we examine the outermost layer for damage caused by algae burrowing into the shell. In addition to algae damage, we study the effects of scratches deliberately made on the shell surface. By performing micro-indentation experiments near these damaged areas, we determine whether and how shell hardness is affected and if there exist characteristics on the shell surface that can be used to indicate what that area's average hardness is expected to be.

SESSION II. POSTER SESSION

REAL TIME-3D SOUND SPATIALIZATION

Alicia Alarie
University of Rochester

The goal of this project is to control the perceived location in three dimensions of a sound source around a listener's head in real time. To allow a listener to reconstruct the location of a sound, head-related transfer functions (HTRFs) corresponding to 187 different locations around the head were used as digital filters. To control the location of the sound, the 3D Connexion Space Navigator mouse was used as an interface between the user and a MATLAB program, which receives the position information from the 3D mouse and translates it into spatial coordinates.

THE AB DOR MOVING GROUP: A CHEMICALLY HETEROGENEOUS KINEMATIC STREAM?

Scott A. Barenfeld, E. J. Bubar, E. E. Mamajek, and P. A. Young
University of Rochester, Marymount University, CTIO, and Arizona State University

The AB Dor Moving Group is the nearest kinematic group to the Sun. It consists of a "nucleus" of ~10 comoving stars at distance ~20 pc (Zuckerman et al. 2004), along with dozens of purported "stream" members spread out across the sky, with distances up to 140 pc away (Torres et al. 2008). We perform a kinematic and chemical analysis of a sample of 10 AB Dor "stream" members to test whether they constitute a physical stellar group. We use the NEMO Galactic kinematic code to investigate the orbits of the stream members, and perform a chemical abundance analysis using high resolution, high S/N spectra taken with the MIKE spectrograph on the Magellan Clay 6.5-m telescope. Using a chi-squared test with the measured abundances for 10 different elements (Fe, Na, Mg, Si, Al, Ca, Cr, Mn, Ni, and Ba), we find that only a few of the ten purported AB Dor stream members appear to constitute a statistically chemically homogeneous sample. Our orbit simulations show that some of the "stream" members were hundreds of pc from AB Dor ~100 Myr ago, and hence were unlikely to have formed near the eponymous star. The lack of kinematic and chemical coherence among the stream sample suggests that the published lists of AB Dor moving group members are unlikely to represent the dispersed remnant of a single star formation episode. Our study does not rule out the physicality of the AB Dor "nucleus" identified by Zuckerman et al., which appears to be coeval with the Pleiades (~120 Myr). We conclude that the AB Dor stream is dynamical in nature, likely containing stars from many different birth sites.
This research was supported by NSF grant AST-1008908, an REU supplement, and funds from the School of Arts and Sciences at the University of Rochester.

A POSSIBLE $^{12}C(n,2n)^{11}C$ TOTAL CROSS SECTION MEASUREMENT

Andrew Evans, Keith Mann, and Mark Yuly
Houghton College

Tertiary neutron production can be used as an indicator of the burn fraction of a deuterium-tritium pellet in inertial confinement fusion reactions. One way to monitor tertiary neutrons is by carbon activation using the $^{12}C(n,2n)^{11}C$ reaction, which has a threshold of 20.3 MeV and so is insensitive to primary neutrons produced in the DT reaction. However, the cross section for this reaction is not well known. Several different experimental techniques for measuring $^{12}C(n,2n)$ have been examined, with an activation experiment being the most feasible.

VISUALIZING THE FLUTE AIR JET

Karen Farbman
University of Rochester

The purpose of this project was to visualize the air jet of the flute. When the flute is played, the air jet produced by the player oscillates in and out of the hole in the lip plate. We employed Schlieren photography, a method that images differences in the index of refraction of the air, to visualize this. The Schlieren system was a two-pass configuration employing a 532 nm green laser as the illumination. The Schlieren image was captured by a high-speed video camera operating at 2000 - 4000 frames per second. To play the flute, compressed, heated air was blown across the flute. By heating the air a higher index of refraction difference was created which aided in the visualization. The video was imported into Matlab, and the intensity versus time of individual pixels in the air stream was analyzed for evidence of oscillation. The frequency of the oscillation found in the video analysis matched the frequency of the sound produced. A clear visualization of the air jet motion is produced, and the detailed video analysis enabled detection of the oscillations. In continuing work, we will visualize the air jet at the note transient to observe any differences.

CHARACTERIZING THE HOUGHTON COLLEGE CYCLOTRON

Nicholas Fuller and Mark Yuly
Houghton College

The Houghton College Cyclotron consists of a 17 cm inner diameter evacuated aluminum chamber containing a “dee” shaped electrode and a grounded “dummy dee” placed between the poles of a 1.2 T electromagnet. Low-pressure gas is introduced into the chamber where a filament, through electron collisions, ionizes the gas. The ions are accelerated in a spiral path by an alternating RF electric field in the constant magnetic field. It is expected that the accelerated ions will reach maximum energies of 400 keV, 200 keV, and 100 keV for protons, deuterons, and helium respectively. The cyclotron has successfully accelerated protons and helium ions. Currently, the performance of the cyclotron is being optimized for future small-scale nuclear experiments.

COHERENT BEAM STIMULATED PARAMETRIC DOWN CONVERSION IN QUANTUM INTERFEROMETRY

Anna Gura, Richard Birrittella, and Christopher C. Gerry
Lehman College

A few years ago, Kolkiran and Agarwal (Optics Express 16, 6479, (2008)) studied the prospect of using the light generated via coherent beam stimulated parametric down-conversion for performing ultra-sensitive phase-shift measurements in quantum optical interferometry. The detection scheme they proposed was to perform coincident photon counts on the two output beams of the interferometer. However, it has been shown that another detection scheme, that being the measurement of photon number parity on just one of the output beams can serve as a universal technique to improve interferometric measurements for almost all conceivable input quantum states. In this work, we investigate the application of that technique for the states generated by coherent beam stimulated parametric down-conversion. We study the phase conditions and joint photon number distributions necessary to approach the highest level of sensitivity allowed by quantum mechanics, the so-called Heisenberg limit.

CAPTURE OF IRREGULAR SATTELITES VIA BINARY PLANETESIMAL EXCHANGE REACTIONS IN MIGRATING PLANETARY SYSTEMS

Imran Hasan, Alex Moore, and Alice Quillen
University of Rochester

By logging encounters between planetesimals and planets, we compute the distri-bution of encounters in a numerically integrated two-planet system that is migrating due to interactions with an exterior planetesimal belt. Capture of an irregular satellite in orbit about a planet through an exchange reaction with a binary planetesimal is only likely when the binary planetesimal undergoes a slow and close encounter with the planet. Taking care to consider where a planet-orbit-crossing binary planetesimal would first be tidally disrupted, we estimate the probability of both tidal disruption and irregular satellite capture. We estimate that the probability that the secondary of a binary planetesimal is captured and becomes an irregular satellite about a Neptune mass outer planet is about 1/100 for binaries with masses and separations similar to transneptunian planetesimal binaries. Scaling functions are given allowing probabilities to be estimated for satellite capture from binary planetesimals with other masses, mass-ratios and separations. This capture probability is only weakly dependent upon the binary's tidal disruption radius. We find that the probability that a satellite is captured by the inner planet is one to two orders of magnitude lower than by the outer planet. If young exoplanetary debris disks contain a population of binary planetesimals then outwards migrating outer planets should host recently captured irregular satellite populations. We discuss interpretation of emission associated with the exoplanet Fomalhaut b in terms of collisional evolution of a recently captured irregular satellite population that has been replenished due to planetary migration.

SIMULATING COULOMB INTERACTING DARK MATTER

Colin Lauer and Christopher M. Wells
Houghton College

While Dark Matter (DM) is known to be the dominant form of matter in the universe through its gravitational effects on visible matter, the microscopic properties are unknown. Astronomical observations and direct detection experiments suggest that DM may have self-interactions. We propose a numerical simulation of the cosmological formation of DM halos under the influence of Newtonian gravity and Coulomb-like self-interactions.

JETS OR CLUMPS IN CRL 618

Bin Lin, Martin Huarte Espinosa, and Adam Frank
University of Rochester

The proto-planetary nebula CRL 618 is an astronomical object formed by a star, as big as the Sun, at the end of its life. CRL 618 is at the short-lived episode during the star's rapid evolution between two phases: the asymptotic giant branch phase and the subsequent planetary nebula phase. We study the formation and evolution of the enigmatic narrow collimated lobes observed in CRL 618. High-resolution 3D hydrodynamic simulations are carried out using the AstroBEAR code. We explore whether a supersonic collimated jet or a supersonic clump, which move though a structured ambient medium, are able to form lobes with morphologies and gas distributions which resemble those in CRL 618. The simulations allow us to investigate the role that thermal energy losses (radiative cooling) and different ambient medium distributions play on the lobes' structure. We consistently find that the lobes of CRL 618 are better modelled by clumps than by jets.

SEARCHING FOR NON-LOCALITY IN TWO-MODE "ARCSINE" STATES AND THEIR SUPERPOSITIONS

Jesse McCaskill, Sachiko Miyazawa, and Christopher C. Gerry
Lehman College

If states of definite and identical numbers of photons (so-called twin-Fock states) simultaneously fall on opposite sides of a 50:50 beam splitter, the output states of the beam splitter are the "arcsine" states of a two-mode optical field, so-called because their joint photon number probability distribution resembles in shape the arcsine distribution of probability theory. The arcsine states are shown to be highly entangled and therefore are expected to exhibit quantum non-locality via the violation of one or more of the various forms of Bell inequality. Yet we have examined several inequalities, the Clauser-Horne-Shimony-Holt, The Clasuer-Horne, and four inequalities proposed by Janssens et al., and we find little evidence of the expected non-locality. The results are striking because a close relative of the arcsine states, the so-called NOON states, strongly do violate these inequalities. We consider the possibility that continuous superpositions of the arcsine states may violate the some of the various Bell inequalities. Specifically, we consider the

state produced by a beam splitter if the input state is a so-called pair-coherent state, a superposition of twin-Fock states, where the output will be a superposition of arcsine states. We report on the results of this search.

DESIGN AND CONSTRUCTION OF A VARIABLE TEMPERATURE ATOMIC FORCE MICROSCOPE

Ethan Ocock and Brandon Hoffman
Houghton College

A variable temperature atomic force microscope (AFM) is being built at Houghton. The AFM will use a spring vibration isolation system with eddy current dampening in order to remove mechanical vibrations from both the machine and external sources. To approach and scan a sample, a modified "Johnny Walker" beetle will be built to move up, down, and across a ramp. Liquid nitrogen and resistive heating will be used to create a range of ~100K - 500K to measure in and increase the temperature range of the AFM. Once complete and fully operational, this AFM will be able to scan samples on the resolution of nanometers, making it useful for many fields of science.

THE HOUGHTON COLLEGE SCANNING TRANSMISSION ELECTRON MICROSCOPE

Mark Spencer and Brandon Hoffman
Houghton College

Houghton College is refurbishing a Jeol JEM CX-100 Scanning Transmission Electron Microscope (STEM) for the study of thin metal films. The STEM is capable of SEM, TEM, XRD, electron diffraction, and backscattered electron microscopy, up to 800,000× magnification. A computer program will be developed to read the x and y raster and create and manipulate digital images. To date, most of the work has been invested in restoring the vacuum system and aligning the electron beam.

STAR FORMATION IN THE NGC 5846 GROUP OF GALAXIES

Lucas Viani
Union College

Environmental interactions in groups and clusters of galaxies are thought to alter the evolution of member galaxies. The goal of this research was to analyze gas and star formation properties of galaxies in the NGC 5846 group. A sample of group galaxies was observed at CTIO (Cerro Tololo Inter-American Observatory in Chile) and KPNO (Kitt Peak National Observatory) using broadband red (R) and narrowband hydrogen emission line (Hα) filters. The images were reduced and analyzed to extract star formation rates and distributions. Neutral hydrogen data from the Arecibo Legacy Fast ALFA (ALFALFA) survey were used to measure the cold neutral gas content, which provides the raw material for star formation. The amounts and extents of the star formation regions in sample galaxies are compared as a function of cold gas content, galaxy type, and position in the group and compared to those of galaxies located in other environments. We find that galaxies in the NGC 5846 group have lower mean star formation rates and gas content compared to isolated galaxies. Truncated star formation similar to that of galaxies in the Virgo cluster is seen in several NGC 5846 galaxies.

SESSION IIIA. HIGH-ENERGY AND NUCLEAR PHYSICS

OPTIMIZING EFFICIENCY OF THE LUX TRIGGER SYSTEM

Brian Degner, Eryk Druszkiewicz, Mongkol Moongweluwan, and Frank L. H. Wolfs
University of Rochester

In the construction of the Large Underground Xenon (LUX) detector, the Rochester group has developed a trigger system that selects the events for the data acquisition system to record. For WIMP studies, the goal of this trigger system is to accept all WIMP candidate events inside the fiducial volume with the correct S1 and S2 signatures and reject all events outside the fiducial volume. The efficiency of the trigger is limited by the number of trigger channels that are available (16) for the 122 LUX PMTs. This requires that the signals from 7 or 8 PMTs are summed and the sum signal is sent to the trigger system. Using a computer model of the trigger system and simulated S2 events, we determine how different variables affect the S2 trigger efficiency. For example, we determine how changing the lower threshold for the input signals from both the PMTs inside and outside the fiducial volume affects the efficiency. We also investigate how the PMT summing configuration affects the S2 trigger efficiency and determine the optimum summing configuration.

SPIN-DEPENDENT FORCES IN HEAVY QUARKONIA

LeighAnn Larkin
SUNY Brockport

A quarkonium, a bound state of a quark and an anti-quark, can provide insight into the interaction of quarks and the structure of nuclear matter. Heavy quarkonium can be modeled straightforwardly using a combination of variational and perturbative techniques. Using a FORTRAN code, which computes energy levels of the b-anti-b quarkonium system, I have investigated spin-dependent interactions occurring between the quark and the anti-quark, and how these forces affect the energy spectrum.

RESISTUINO: AN ULTRA PURE WATER-MONITORING DEVICE FOR THE DAYA BAY CORE NEUTRINO EXPERIMENT

Kyle Turck and Dr. John Cummings
Siena College

Resistuino is a custom resistivity and temperature monitor system. This system uses an Arduino Mega board in conjunction with an Arduino Ethernet Shield and a circuit board designed by Kyle Turck with assistance from Joe Kujawski and Dr. John Cummings at Siena College. This device will be used to monitor the ultra pure water in the muon veto detectors of the Daya Bay Core Neutrino Experiment in Daya Bay, China. We chose to design and build a custom monitoring system to help reduce the budget of the experiment. A similar commercially produced system would about $75,000, Resistuino will cost between $2,500 - $5,000 to produce, with an accuracy of 10%.

SESSION IIIB. CONDENSED MATTER PHYSICS

METHOD FOR BUILDING A MUTUAL INDUCTANCE BRIDGE FOR THE PURPOSE MEASURING MAGNETIC SUSCEPTIBILITIES.

Chris Knupp
SUNY Brockport

Seeking to find the magnetic susceptibility of samples as they transition to super conducting, we investigate mutual inductance and how magnetic susceptibility can be measured using a Mutual Inductance Bridge, MIB, as part of an AC Susceptibility circuit. In this circuit we can measure the back emf and relate that to the magnetic susceptibility of a sample. To make this measurement at known temperatures our MIB needs to be designed and built such that it can fit into our cryostat system with the sample resting in the Helium bath and generate as little heat as possible. The MIB is comprised of three coils, one primary (2.54 cm dia., length 7.6 cm, and about 10,000 turns) and two secondary (wrapped around the primary, are counter-wound to each other, length 2.5 cm, separation 2.0 cm, and about 7,000 turns). The gauge of the copper wire used is 42.5 (~60 micrometers dia.) and 44.5 (~50 micrometers dia.) for the primary and secondary coils respectively. A human hair is approximately 100 micrometers. The winding of these coils uses a modified lathe driven by two stepper-motors powered by a 5 V power supply all of which is automated by two control boards.

EXPERIMENTAL INVESTIGATION OF SILICON POWDERS USING X-RAY DIFFRACTION

Jordan Metz McLeod
SUNY Brockport

The purpose of this study was to use the x-ray diffractograms of Silicon crystallites of known sizes to determine their parameters for use in Scherrer's Formula. Scherrer's Formula allows for the determination of the size of crystallites in a polycrystalline sample. Data was procured through the application of copper-source x-rays onto Silicon samples of different grain size, over a range of incident angles corresponding to known peak centers found using Braggs' Law. Braggs' Law was used to determine the locations of peaks for analysis and to verify the structure of the crystallites. This data was then analyzed to obtain specific peak characteristics: peak width, peak shape, peak height, half-width half-maximum. Using the experimental peak width and the known crystallite size, the constant in Scherrer's Formula was determined.

THE ORIENTATION DEPENDENCE OF NBTI DEGRADATION IN PMOS FINFETS

J.W. Pater, C.D. Young, K. Matthews, G. Bersuker, and A. Weatherwax
SEMATECH and Siena College

One particular transistor type that can achieve reduced power consumption and maintains the performance compared to currently used planar transistors in current microprocessors is the three-dimensional (3D) device structure known as Fin Field Effect Transistor (FinFET). These devices were subjected to Negative Bias Temperature Instability (NBTI) to assess the reliability. It was found that the (110) channels experience larger levels of degradation than the (100) channels and, as fin doping increases, degradation worsens. This project has determined that the (100) oriented FinFETs are less susceptible to NBTI degradation compared to (110) oriented FinFETs.

PRODUCTION AND CHARACTERIZATION OF ELECTROSPUN NANOFIBERS

Anna Sise and Professor Seyfollah Maleki
Union College

Electrospinning is a process of generating polymer fibers by accelerating a polymer solution through an electric field.[1] The polymer solution is released at a designated rate through a syringe; once the droplet enters the high voltage region, it whips throughout the chamber, landing upon a grounded collector. This procedure results in fibers with a range of diameter from several nanometers to a few micrometers.[2] These fibers can be used in a variety of applications, including drug delivery, filter media, material substrates, optical media, tissue scaffolds, and wound dressing.[1]
For my senior thesis, I established the most successful method of creating nano-fibers and documented the qualities and characteristics of these fibers using optical and Atomic Force microscopy. I investigated creating polymer fibers using different solutes and experimented with gold nano-particles additives. In my future experiments, I want to generate nano-fibers with other additives such as carbon and quantum dots and measure the physical characteristics, both optically and electrically.

[1] Ramakrishna, Seeram, Kazutoshi Fujihara, Wee-Eong Teo, Teik-Cheng Lim, and Zuwei Ma. An Introduction to Electrospinning and Nanofibers. Singapore: World Scientific, 2005.

[2] Fitzgerald, Jesse. Production of Electrospun Polymer Fibers with Embedded Quantum Dots. Thesis. Union Graduate College, 2008.

SESSION IIIC. EXPERIMENTAL TECHNIQUES

DELAY LINE DETECTION

Dr. Allan Weatherwax, Joseph Kujawski, Robert Carroll, Steven Atkinson, Shane McMahon, and Ian Gilchrest
Siena College

The Goddard Thermal Electron Capped Hemisphere Spectrometer (G-TECHS) is an instrument concept intended for sounding rocket applications. Siena College is working on a novel method of processing information from electron spectrometer receiver anodes using delay line techniques and inexpensive COTS electronics.
Electron spectrometers use a variety of techniques to determine where the amplified electron cloud falls onto a collecting surface. One traditional method divides the collecting surface into sectors and uses a single detector for each sector. However, as the angular and spatial resolution increases, so do the number of detectors that are needed. Thus, there is an overall increase in power consumption, cost, size, and weight of the detector system.
We are working on an alternative approach connecting each sector with a delay line built within the PCB material and using a pair of detectors (e.g., one at each end of the chain). This is a different approach from traditional delay line detectors that either use Application Specific Integrated Circuits (ASICs) or very fast clocks. We report on the implementation and testing of a delay line detector using a low-cost Xilinx FPGA. Our technique is scalable to large sector numbers with very little impact on the system cost, mass, or power dissipation. The specifics of both a prototype 32-sector system intended for a sounding rocket application will be discussed.

REDUCING DOSE WHILE MAINTAINING IMAGE QUALITY FOR CONE BEAM COMPUTED TOMOGRAPHY

Peter Kroening and Brian Winey
Houghton College and Harvard Medical School

Three-dimensional volumetric cone beam imaging, or cone beam computed tomography (CBCT) scans were taken of a quality assurance Catphan phantom, human pelvis phantom, and human head phantom at the Department of Radiation Oncology at Massachusetts General Hospital. Preset values of the gantry speed and the pulse current were varied to adjust the dose delivered for CBCT scans. The CBCT images were analyzed in MatLab for image quality as a function of the dose received by the phantom. Radiation dose was measured with an electrometer for the various preset combinations. If the elapsed time of a scan can be decreased and the pulse current lowered while maintaining adequate image quality than the average radiation delivered to a patient can be decreased. This analysis helped showed that the image quality is maintained for faster scans with lower currents such that patients will be exposed to lower levels of dose.

PHYSICAL CONCEPTS OF GROUND PENETRATING RADAR

Alexandria Kuhl
The College at Brockport, SUNY

This research is to study the physics behind ground-penetrating radar (GPR) for better understanding and interpretations of GPR imaging. GPR is a surveying tool that can identify features in the subsurface through the transmission and reception of electromagnetic (EM) waves that reflect off of boundaries where dielectric constants differ. Starting with Maxwell's Equations and deriving the EM wave propagation through matter, the behavior of waves as they reflect off boundaries is described. Additionally, the dispersion relation regarding the attenuation of waves as they travel through matter was obtained and used to predict the maximum depths of radar penetration.

Over 2 km of GPR imagery was collected at a study site and interpreted to correlate predicted maximum depths with those actually observed. A dielectric constant of 36 was obtained for the field site using the signal of a strong reflector at a known depth. This value was then used in the dispersion relation to produce the results.

This research will help assess the suitability of GPR for mapping soil depths on the Onondaga Formation in Genesee County, NY. This highly agricultural area is prone to groundwater contaminations that may be prevented through identifying thin soils with GPR.

MULTIPLATE CHAMBER CONSTRUCTION AND OPERATION

Jonathan Slye and Mark Yuly
Houghton College

Multiplate chambers can be used as a source for high current, high voltage ion beams via pseudo-spark discharge. A five gap, untriggered multiplate chamber has been constructed at Houghton College, to operate at voltages up to -25 kV and pressures between 25 and 80 mTorr. The discharge occurs when the voltage across a 2.7 pf capacitor, which is charged through a 400 MW current limiting resistor, reaches the breakdown voltage of the air in the device. The discharge voltage at several operating pressures has been measured by monitoring the current flowing into the capacitor, and the beam current as a function of time has been measured using current divider with an oscilloscope. The shape of the beam spot has been observed using a phosphor screen.

SESSION IVA. ASTRONOMY II

PHOTOMETRIC CAPABILITIES OF THE SUNY BROCKPORT OBSERVATORY

Kevin Grossman and Eric Monier
SUNY Brockport

The Observatory at the College at Brockport contains a fixed 10” Meade telescope and a CCD camera for capturing images. In this contribution, I describe my efforts to characterize the photometric accuracy that can be achieved at the campus site. Photometry is the measurement of the apparent brightness of astronomical objects. Precise measurements of stars are necessary, for example, if the goal is to measure brightness variations over time. While some stars vary naturally, others are “eclipsed” by companion stars or planets, causing the light that reaches us to decrease for a period of time. Our goal is to determine if the setup at the Brockport Observatory is sensitive enough to detect extra-solar planets. Other studies using small telescopes have been able to detect extra-solar planets by measuring brightness changes as small as 1%. By obtaining light curves of variable stars having known brightness variations and comparing them to stars of well-determined, constant magnitudes, I will determine whether detection of extra-solar planets is feasible at Brockport.

CLASSIFYING PLANETARY SPECTRA AND THE SEARCH FOR AN EARTH ANALOG USING ARTIFICIAL NEURAL NETWORKS

Nathan Levine
Siena College

NASA hopes to eventually build a space telescope to obtain spectra of Earth-like planets orbiting other stars in order to search for signatures of life, such as atmospheric oxygen. We are simulating the capabilities of a range of possible instruments for such a spacecraft using a supervised data mining technique known as an artificial neural network. We start with model planetary spectra for hypothetical and real planets, including Jupiter, Mars, Venus, the Earth with life, the Earth before oxygen-producing life, the Earth without life, and other variations. We then degrade these model spectra to a range of realistic spectral resolutions and signal-to-noise values. We train multiple feed-forward back-propagation networks to find the architecture that optimizes the classification accuracy. In many cases the network was able to achieve a 95% classification accuracy with modest signal-to-noise. Based on these experiments we are able to determine the basic performance capabilities and trade-offs for a space-based telescope capable of detecting life-bearing planets.

HERSCHEL SPECTROSCOPY OF PROTOSTARS IN ORION: FAR-INFRARED CO EMISSIONS

Vincent Yu, Manoj Puravankara, and Dan Watson
University of Rochester

Infrared spectroscopy is a powerful tool to probe the excitation conditions and chemical compositions of warm (~300 K) and hot (~1000 K) gas in the vicinity of protostars. We obtained 57-190 μm spectra of 32 protostars in the Orion Molecular Cloud Complex as part of the Herschel Orion Protostar Survey. These protostars span a large range of luminosities (1-300 solar luminosities) and display different line emission profiles. We modeled and analyzed the CO rotational emission lines seen in the far-infrared spectra to constrain the density and temperature of the emitting gas. We searched for correlations between these physical conditions of the gas and protostellar properties such as the bolometric luminosity and temperature. We will present the results of this study and discuss the implications for our understanding of the early stages of star formation.

SESSION IVB. EXPERIMENTAL AND TEACHING TECHNIQUES

THE MONOCHROMATOR

John Gardner
SUNY Brockport

The goal of this project is to refurbish an old Monochromator and optimize it for use in future labs. The device was tested to ensure basic functionality and to determine the best way to approach the project. A detection circuit was built to allow data from the device to be collected by a computer. This was done using a photodiode to detect changes in light and an operational amplifier to boost the signal. LabView software was used to interpret the data sent to the computer and create an output file that could be easily understood. The data collected during tests was then analyzed in order to establish the limitations of the device and its possible uses in future labs. These tests included viewing the light spectra of various gases such as Sodium, Hydrogen and Deuterium. A lab manual containing directions and lab experiments was written to assist future students.

FINDING CONNECTIONS: REGENTS VS AP IN THE COLLEGE CLASSROOM

Stephanie Kinney, Dr. Rose Finn, and Dr. Michele McColgan
Siena College

Faculty in the Siena College Department of Physics and Astronomy have been administering the Force Concept Inventory (FCI) test to General Physics classes for the past several years. It is used to determine the Hake scores (actual gain/ potential gain) for every student that enters and leaves the classroom. As part of the assessment, the students' high school physics experience was also recorded. For this research the students who had taken AP, Regents, Honors, and other types of physics classes were separated into groups and then their Hake scores were compiled within each category and averaged. This was done in order to see if there was some indication that the students who took Regents physics in high school were at some sort of disadvantage when they came to a college level physics course. The preliminary results indicate that there is some disadvantage for the Regents students as there Hake score average is about 20 points lower than the AP student average. The other sections show no correlation to the AP and regents data.

ANALYSIS OF BIFURCATION TRENDS IN POPULATION MODELS APPROACHING CHAOS

Charles Schultz and Raymond Nelson
United States Military Academy

In this study we have used a computer algebra system, Mathematica, to explore the fine details of population models based on difference equations. We have explored the dependence of the length and nature of the transient behavior in the bifurcation regime to the proximity of the starting point to an attractor. We have also compared and contrasted the structure of the bifurcation regime for different population models with similar amplitude parameters and looked for any similarities in the appearance of islands of stability that appear after the initial transition to chaotic behavior. The use of Mathematica with high floating-point precision has allowed us to identify even very small such islands and to accurately determine their periodicity.

A REVIEW OF INDEPENDENT COMPONENT ANALYSIS

Robert Zimmerman and Dr. Larry Medsker
Siena College

Independent Component Analysis (ICA) is a statistical and computational technique that can be used to separate a multivariate dataset into its sub components. The fastICA program used in MATLAB finds the independent signals that were responsible for the creation of the complex signal. The method has already proved to be valuable and convenient in analyzing nuclear physics data. This method was used to examine other data in various areas of science and technology. Given the success in the field of technology, fastICA was tested for its effectiveness in other situations not pertaining to science. In this study the datasets being observed are key word instances that were created by text retrieval from social media sources. FastICA analyzed these key words of interest in society to find any connections or correlations between particular key words. Evidence of key words showing a relationship with one another over time could potentially lead to predictions of significant events in society occurring in the future based on the activity of certain key words. This study has been in collaboration with Siena College Institute for Artificial Intelligence (SCIAI).

SESSION IVC. QUANTUM OPTICS

PAIR-COHERENT STATES AND QUANTUM OPTICAL INTERFEROMETRY

Richard Birrittella, Christopher C. Gerry, and Jihane Mimih
Lehman College

Quantum optical interferometry can approach the ultimate limit of sensitivity in phase-shift measurements allowed by quantum mechanics, the so-called Heisenberg-limit, by simultaneously allowing twin photon numbers states, of high photon number, to fall on opposite sides of the first beam splitter of a Mach-Zehnder interferometer. At the output of the interferometer, one must perform photon number parity measurements to obtain Heisenberg-limit sensitivity, and the input photon number should be large. But twin-number states, which have sub-Poissonian statics in the extreme, are very difficult to generate, especially for high photon number. An alternative is to consider using continuous variable states that consist of superpositions of the twin-number states where the overall statistics are still sub-Poissonian. The pair-coherent state is of this type. In this presentation, we describe the use of the pair-coherent state in interferometry and we describe a state-projection method by which the states could be generated.

QUANTUM OPTICAL INTERFEROMETRY WITH PHOTON-SUBTRACTED TWO-MODE SQUEEZED VACUUM STATES

Raul Carranza and Christopher C. Gerry
Lehman College

Quantum optical interferometry can approach the ultimate limit of sensitivity in phase-shift measurements allowed by quantum mechanics, the so-called Heisenberg-limit, by simultaneously allowing twin photon numbers states, of high photon number, to fall on opposite sides of the first beam splitter of a Mach-Zehnder interferometer. At the output of the interferometer, one must perform photon number parity measurements to obtain Heisenberg-limit sensitivity, which scales as the inverse of the total photon number, and the input photon number should be large. But twin-number states, which have sub-Poissonian statics in the extreme, are very difficult to generate, especially for high photon number. An alternative is to consider using continuous variable states that consists of superpositions of the twin-number states. The obvious and most readily available state to use is the two-mode squeezed vacuum state generated via spontaneous parametric down conversion. The problem is that the photon statistics for these states is highly super-Poissonian and is thermal-like with the state of highest occupation probability is the twin vacuum state. And for practically generated states of this sort the average photon number both the average photon for such states is relatively low. Also, the phase uncertainty is very unstable with respect to the phase shift itself, rapidly drifting away from the Heisenberg limit with increasing photon number. We propose to alter the distribution by performing photon subtractions on the output beams that counter-intuitively increases the average photon number. The performance of the photon-subtracted states in interferometry is improved over that for the two-mode squeezed vacuum states.

QUANTUM RANDOM WALKS IN PHOTONIC WAVEGUIDE LATTICES

Christopher Mullarkey[1], Dr. Stefan Preble[2], Dr. Andrew Robinson[1], and Dr. Edwin Hach[1]
[1] Department of Physics, Rochester Institute of Technology
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The ability to describe the evolution of quantum states of light is key to designing devices that exploit quantum entanglement as a part of their operation. Here the formal Bloch-wave solution to an arbitrary photon field state evolving in a waveguide lattice is presented. A program that integrates the Schrödinger Equation via the Taylor Method is described that allows for the evolution of an arbitrary superposition state to be simulated in this system. Whereas the single photon case mimics the trajectory of a classical field state, a result verified by simulations using the Beam Propagation Method, any higher number of photons can give rise to quantum interference and is properly described as a quantum random walk. Though in general the final state is in a very complicated superposition, it will also be shown that desirable quantum behavior, such as Hong-Ou-Mandel interference, appears in this continuous system.

GENERATING A FOUR QUBIT LINEAR CLUSTER STATE

William Schubert and Enrique Galvez
Colgate University

We investigate a method for generating a four-qubit linear cluster state consisting of polarization entangled vector beams. First, two polarization-entangled photons are created via down-conversion and then each is diffracted into a vector mode. A photon is said to be in a vector mode when its spatial distribution and polarization are entangled. The addition of vector modes gives the system an additional degree of freedom allowing for a four-qubit cluster state of only two photons.
Qubits are the building blocks of quantum computers. The cluster state we plan to demonstrate could be used in one-way quantum computing, where gates are replaced by measurements on different types of cluster states. Our linear state can be transformed into both the horseshoe and box states with some manipulation of polarization and spatial mode.

QUANTUM PROPERTIES OF LIGHT

Alex Dunn
Rochester Institute of Technology

This paper deals with the experimental investigation of the quantum nature of light. A single photon light source was developed based on spontaneous parametric down-conversion (SPDC) in a non-linear crystal [beta barium borate (BBO)]. The non-linear susceptibility of the crystal allows for the production of two photons that are strongly correlated in energy and momentum. With an additional, but orthogonal BBO crystal, it is possible to demonstrate polarization entanglement of these two photons, a truly quantum mechanical phenomenon. In order to test the non-locality of the entanglement we carried

out Bell Inequality measurements and observed S=2.412 ± 0.113. This is a clear violation of the Bell Inequality by over 3 standard deviations, disproving local Hidden Variable Theories (HVT's). We also demonstrated that a quantum mechanical state yields a classical result in interferometry. Using a light beam attenuated down to the single photon level, the interference pattern was measured to emulate that of a classical diffraction pattern.

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