XXVII
ROCHESTER SYMPOSIUM FOR
PHYSICS (ASTRONOMY & OPTICS) STUDENTS
SPS Zone 2 Regional Meeting

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ABSTRACTS

Condensed Matter, Quantum Optics, and Biological Physics

A Study of Tailored Oriented Microstructures in Thin Silver Films using Scanning Electron Microscopy (SEM) and Electron Backscatter Diffraction (EBSD)

Bethany Little and Brandon Hoffman
Advisor: Prof. Mark Yuly, Houghton College

Thin silver films have a variety of important applications but are not presently well understood. The growth and microstructure of the films directly affects the compliancy and stiffness, and thus the strength, of these films. Using a scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD), the microstructures of silver films created with a range of thicknesses, titanium adhesion layers, and annealing temperatures, have been analyzed.

Series Resistance Measurements of Nanostructured Solar Cells

Elliott Miller
Advisor: Prof. Seth Hubbard, Rochester Institute of Technology

Solar cells are solid state devices designed to take energy from light and generate power, and current research on them is focused on increasing their capability. This project is focused on internal resistances. To extract these different characteristics, a dark I-V curve and a short circuit current-open circuit voltage current is measured. The latter is accomplished by measuring the cell when sourced at zero voltage and current, respectively, over a range of light intensities.

For this project, phase 1 consisted of building a complete experimental apparatus and phase 2 consisted of improving measurements and undergoing a study. The setup is programmed in Labview and can take and record all data automatically. For the study, 28 cells were measured across 4 wafers. Three wafers consist of dot cells, with two being doped with tellurium, and the third, our baseline wafer, containing an intrinsic (un-doped) layer. The doped wafers showed the lowest series resistance. The baseline wafer had the highest average fill factor and efficiency.

Optical Isolator

Jane Cornett
Advisor: Prof. Kenneth Segall, Colgate University

One of the biggest problems in low-temperature physics experiments is noisy data. The project I have been working on has been an attempt to reduce noise by isolating the experimental ground from the earth ground. We have done this by building and implementing something called an optical isolator.

Automated Beam Positioning and Control for a Double Pump Probe Experiment

Cadet Chi-Feng Ching
Advisor: Lieutenant Colonel John Hartke, United States Military Academy, West Point

A double pump-probe experiment is used to measure the nonlinear optical properties of materials, and it requires the probe beam to intersect with the double pump beams exactly on the sample, in order for our measurements to reflect the opacity of excited materials accurately. The goal of this project is to design an automatic realigning program to prevent the probe beam from wandering off the sample during the data collection process in the double pump-probe experiment. Our solution is designed to correct the incident location of the probe beam and optimize the experimental data. The expectation of the project is to maintain the probe beam location on the sample within an acceptable uncertainty range of 0.01 millimeters.

Information Rate Optimization of the Squid Giant Axon

Jeffrey Seely
Advisor: Prof. Patrick Crotty, Colgate University

My research explores the information rate of neurological activity (i.e. action potentials). Specifically, I look at the squid giant axon, which is a well-understood neurological component in nature. The information rate of the squid giant axon is determined by how quickly two successive action potentials can be generated. Using computer models of the squid giant axon we can change some of its parameters (e.g. increase its diameter, or decrease the density of ion channels in its membrane), which may change the information rate. Ultimately, I run simulations to test whether evolution has “designed” the squid giant axon in such a way as to maximize information rate.

Poster Session

Design and Construction of a Deposition Chamber for Thin Metal Films Research

Kurt Aikens and Brandon Hoffman
Advisor: Prof. Mark Yuly, Houghton College

A high vacuum deposition chamber is being built at Houghton College for studies of thin metal films. Metal atoms evaporated via an electron beam will contact a silicon wafer at near normal incidence, growing a uniform thin film. An ion mill will be constructed for cleaning the silicon wafers and for ion beam assisted deposition (IBAD). A computer-controlled shield will enable deposition of samples of varying thickness

The Houghton College Cyclotron: Results and Modifications

Daniel Haas and Andrew Loucks
Advisor: Prof. Mark Yuly, Houghton College

The Houghton College Cyclotron consists of a 17 cm inner diameter, 2.8 cm thick evacuated aluminum chamber containing a “dee” shaped electrode and a grounded “dummy dee” placed between the poles of a 1.1 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 a constant magnetic and an alternating RF electric field. It is expected that the accelerated ions will reach energies of 280 keV, 140 keV, and 70 keV for protons, deuterons, and helium respectively, and may be used in small-scale nuclear experiments. The cyclotron successfully accelerated protons on one occasion, but after an hour of operation a discharge occurred which destroyed the filament and the surrounding insulation, and a leak in the vacuum chamber developed. To solve this problem, a new larger chamber was designed and is under construction

Experimental Nuclear and Particle Physics

Construction of an NMR System for Measurement of Fundamental Symmetries

Jason Laffin
Advisor: Prof. Mark Rosenberry, Siena College

Careful observation of the precession frequency of an atomic spin may allow us to detect physics beyond the Standard Model, such as CPT-violation. Even a null measurement allows us to set an upper limit on the magnitude of those effects, and thus provide a test of theories of elementary particle physics.

We use a laser system to optically pump rubidium, which then polarizes a noble gas through spin exchange. Our low-field NMR system can listen to the precession of the atomic nuclei when they are "kicked" off axis by a transient magnetic field. The construction of the apparatus will be discussed, along with an update on our preliminary work with xenon.

Cosmic Ray Muon Imaging and Decay and Capture Process Detection

Elizabeth Pollock
Advisor: Prof. Udo Schröder, University of Rochester

Muons are charged particles created in the Earth's upper atmosphere by cosmic ray protons. Utilizing this influx of muons can be a cost-effective way of detecting high-Z materials. These muons can be measured utilizing scintillation detectors. To create an image, the muons are stopped in an object of interest (the target). To accomplish this, the muons are slowed down with sheets of Cu moderator. Once stopped, the muon decays into an electron and neutrino. The decay electrons can easily be detected with scintillation detectors. The five detectors used to facilitate this experiment were constructed and mounted in a frame. The setup allows for the measurement of incident muons and decay electrons. This project was supported in part by NSF award PHY-0552695.

Neutron Induced Deuteron Breakup

Steve Thomson and Daniel Haas
Advisor: Prof. Mark Yuly, Houghton College

A measurement of the differential cross section for neutron-induced deuteron breakup was performed at the LANSCE/WNR facility at Los Alamos National Laboratory. Theoretical calculations have suggested that the deuteron breakup cross section may be sensitive to the presence of a three-nucleon component to the strong nuclear force, especially for protons and neutrons at small scattering angles far from quasielastic kinematics. In this experiment, a permanent magnet spectrometer was used to detect protons and an array of large plastic scintillators was used to detect neutrons, with both detectors at small forward angles on the same side of the beam line. Data analysis from this experiment has not yet been completed.

Hadronic Jets and Clustering Algorithms in CMS

Zhengqing Qi
Advisor: Prof. Regina Demina, University of Rochester

The LHC is a proton-proton collider designed to search for new physics at the TeV scale. Many processes of interest contain partons in the final state, which are not directly observable but transform into stable particles though hadronization. The CMS detector is one of several detectors built at the LHC with tracking and calorimeter systems that can detect these hadrons. The implementation of jet clustering algorithms allows the reconstruction of the hadronic energy as a jet. Proper jet reconstruction is required to yield a good description of the parton-level hard interaction. The SISCone algorithm is designed to account for infrared and collinear issues found in other jet construction algorithms. Performance tests, using QCD dijet Monte Carlo events, reveal that SISCone has equal performance compared to current algorithms. It is proposed that SISCone becomes the default cone based algorithm for CMS.

<u>**Analysis of Momentum Resolution in VLE Beamlines**</u>

Jordan Webster
Advisor: Prof. Regina Demina, University of Rochester

CERN's four beamlines—H2, H4, H6, and H8—are used today as testing facilities for the calorimeters operating in the CMS (Compact Muon Solenoid) detector. When these beams operate at energies much greater then 10 GeV, their momenta can be measured consistently with a respectable level of accuracy. However, at very low energies (less then 10 GeV), measurements of the beam's momentum become relatively inconsistent. Though it has been observed for quite some time, the poor momentum resolution of the low-energy beams is not yet fully understood. An EGS5 simulation of a small section of the H2 beamline was designed and implemented in hopes of learning how to generate a better defined low-energy beam. Data output from the simulation provides a basic reference for tuning and adjusting various beam elements. A preliminary analysis suggests that the poor momentum resolution in the beams could in part be attributed to an insufficient use of accurate detectors.

Theoretical Particle Physics

Non-Standard Couplings in Third Generation Vertices

Stephan Piotrowski
Advisor: Prof. Charles Nelson, Binghamton University

The third generation top quark at 175 GeV is two orders of magnitude more massive than the next third generation quark, the bottom quark, at 4.5 GeV. This fact, along with special patterns in the helicity amplitudes in $t \to W^+ b$ decay, suggests that there may be additional couplings beyond those of the Standard Model in third generation vertices. Such additional couplings, however, can produce unitarity divergences in very high energy collisions. We find such a divergence in the $t\bar{b} \to W^+ Z^0$ process by expanding each calculated helicity amplitude in powers of *E*. A promising modification of the $tZ\bar{t}$ vertex to cancel this divergence is currently being investigated.

Para-Majorana Fermions

Joshua Julian
Advisor: Prof. Charles Nelson, Binghamton University

In general, the Boson and Fermion canonical commutation relations of Quantum Field Theory (QFT) have provided a solid theoretical framework for the probabilistic analysis of field properties. However, there is no reason *a priori* why QFT ought to be utilized in this respect over an alternate field theory for particles with more general statistics, called "parastatistics" or "para-field theory" (pQFT). An interesting application of pQFT is to neutrinos. Among the open questions in neutrino physics—and in particular, the nature of neutrino mass—is whether or not neutrinos are Dirac or Majorana Fermions. In order to engage with this question at the level of pQFT, a theoretical model for para-Majorana Fermions with (V-A)-bias will be presented.

Normal Ordered Matrix Representation and Paraparticle State Space

Shan Huang
Advisor: Prof. Charles Nelson, Binghamton University

The realm of Quantum Theory historically began with the quantization of particle observables from canonical variables and was then extended into the second quantization of Quantum Field Theory. While the successes and applications of such theories are undeniable, these quantizations assume that all particles in nature are either Fermions, which occur in asymmetric states, or Bosons, which occur in symmetric states. Para-Quantum Field theory offers a general scheme of quantization, describing particles that do not obey the well known Bose-Einstein and Fermi-Dirac statistics through the introduction of a new parameter p which dictates the maximum number of fermions (bosons) that can exist in completely symmetric (asymmetric) states. For ordinary bosons and fermions, it is very useful to rewrite operators in a normal ordered form in which all particle annihilation operators are on the right side and all particle creation operators are on the left side. An explicit treatment of projection operators for the single mode Parafermionic state space in a (p+1) X (p+1) normal ordered matrix (NOM) representation gives us a set of natural normal ordered relations. Since Parabosons have no uppermost state, a NOM treatment of Parabosonic state space gives no additional relations.

Discussion of Projection Operators and Para-Fock Spaces

Matthew Dornfeld
Advisor: Prof. Charles Nelson, Binghamton University

In this presentation, we will discuss some of the basic principles of a generalized quantization method in quantum field theory. We will derive the commutation relations that describe the algebraic structure of a new Fock space by making a new definition of the number operator, only assuming the orthonormality and closure of the space. We also will define the structure of this Fock space, which will be called a para-Fock space. Lastly, we will elaborate on the projection operators, which project a state onto one of its components.

Discussion of the Projection Operators for One and Two Mode Parafermions

Dustin Pardo
Advisor: Prof. Charles Nelson, Binghamton University

In this presentation, we will discuss projection operators and the normal-ordering of creation and annihilation operators in a single-mode. We will also discuss how projection operators allow us to determine the algebraic structure of the state space in one-mode, as well as the ongoing work in two-modes.

Astronomy

The Dependence of Galaxy Colors to Magnitude and Environment at 05<z<1.5

Konstantinos Vilaetis
Advisor: Prof. Eric McKenzie, Colgate University

We analyze the FLAMEX and NDWFS public survey data to show relations of color to magnitude and galaxy environment (density of galaxies). Our redshift range was limited between z=0.5 and z=1.5. The data constituted of ~38000 galaxies, with information on 5 filters, Bw, R, I, J, Ks. The data was analyzed to provide information about galaxy distances and surface densities. Then the absolute magnitudes were calculated and k-corrections were applied. Color-magnitude plots were made, showing two distinct red and blue galaxy populations. Color histogram grids were created, arranged by density, magnitude, redshift and color, showing the two peaks of the two populations. One blue and scattered, called the "blue cloud," and one redder, fainter and concentrated, the "red sequence". Dependence on density and magnitude was seen, with denser and brighter galaxies being mostly red.

Data Reduction Procedures for the SUNY Oswego/NOAO/University of Illinois IR LMC Survey

T. Rooker and F. Ripple, D. Crain, G. Feiden
Advisors: Profs. Sashi Kanbur, L. Macri and C. Ngeow, State University of New York at Oswego

In collaboration with the National Optical Astronomical Observatory (NOAO) and the University of Illinois, SUNY Oswego has undertaken a large infra-red survey of LMC Cepheids in the JHK wavebands with the goal to provide accurate JHK Cepheid light curves to OGLE LMC Cepheids. These observations will be useful in examining the nonlinearity of the LMC Cepheid PL relation at infra-red wavelengths. They will also be useful for researchers studying the geometry of the LMC and for infra-red surface brightness methods aimed at reducing zero point errors on the LMC distance modulus and hence the extra-galactic distance scale.

The data consists of over 30 nights of observations taken with the CTIO 1.5 telescope plus CPAPIR CCD in Chile from November 2006 until December 2007. We present data reduction methods using IRAF appropriate for analyzing this large dataset.

Photometry Procedures for the SUNY Oswego/NOAO/University of Illinois IR LMC Survey

Frank Ripple and Travis Rooker
Advisors: Profs. Sashi Kanbur, L. Macri and C. Ngeo, State University of New York at Oswego

In collaboration with the National Optical Astronomical Observatory (NOAO) and the University of Illinois, SUNY Oswego has undertaken a large infra-red survey of LMC Cepheids in the JHK wavebands with the goal to provide accurate JHK Cepheid light curves to OGLE LMC Cepheids. These observations will be useful in examining the nonlinearity of the LMC Cepheid PL relation at infra-red wavelengths. They will also be useful for researchers studying the geometry of the LMC and for infra-red surface brightness methods aimed at reducing zero point errors on the LMC distance modulus and hence the extra-galactic distance scale.

The data consists of over 30 nights of observations taken with the CTIO 1.5 telescope plus CPAPIR CCD in Chile from November 2006 until December 2007. We present photometry techniques using DAOPHOT appropriate for analyzing this large dataset.