University of Rochester, April 15, 2023

Dear Participants:

Welcome to the 41st 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 online at: http://www.pas.rochester.edu/news-events/rsps/2023/index.html

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 American Physical Society (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: https://www.pas.rochester.edu/undergraduate/reu/index.html

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

PRESENTER	TIME	ROOM
MILES ACKERMAN	2:00 PM	B&L 109
MARS ANDERSEN	10:00 AM	B&L LOBBY
AIDAN BACHMAN	10:00 AM	B&L LOBBY
BRIAN BAUER	2:15 PM	B&L 109
ALLISON BLUM	10:00 AM	B&L LOBBY
MATTHEW BOWMAN	9:00 AM	B&L 106
CAMERON BROCHU	10:00 AM	B&L LOBBY
ADAM BROWN	9:15 AM	B&L 106
ROBERT COLLIER	1:45 PM	B&L 106
MICAH CONDIE	11:00 AM	B&L 106
SAMANTHA DEMONTE	2:15 PM	B&L 106
VINCENT DAVIERO	1:45 PM	B&L 109
HENRY DUGGINS	11:30AM	B&L 106
KEVIN EUSCHER	10:00 AM	B&L LOBBY
ISSAC ESCAPA	11:30 AM	B&L 106
OWEN FALL	10:00 AM	B&L LOBBY
YINQI FANG	11:00 AM	B&L 109
HEATHER FLANAGAN	10:00 AM	B&L LOBBY
NOAH FRANZ	9:00 AM	B&L 109
NICOLE HAO	9:15 AM	B&L 109
WALY KARIM	11:00 AM	B&L 109
CHUNSUN LEI	10:00 AM	B&L LOBBY
ANDREW MARTIN	10:00 AM	B&L LOBBY
THOMAS MCENTIRE	10:00 AM	B&L LOBBY
BHAVYA MISHRA	9:30 AM	B&L 109
JESSICA NAGASAKO	10:00 AM	B&L LOBBY
RYAN O'CONNOR	2:30 PM	B&L 109
TIMOTHY OCKRIN	10:00 AM	B&L LOBBY
KEOPASITH PHAPHANTHONG	10:00 AM	B&L LOBBY
KATIE PITTMAN	2:45 PM	B&L 109
HUGH RILEY RANDALL	11:15 AM	B&L 109
SHAIB SHARHAN	11:15 AM	B&L 106
KALE SHEETS	2:00 PM	B&L 106
COLIN STEINER	10:00 AM	B&L LOBBY
SEAN THEISEN	10:00 AM	B&L LOBBY
JOSH WILSON	9:30 AM	B&L 106
JACOB WUNDERLICH	9:45 AM	B&L 109
ZACH YEK	11:30 AM	B&L 109
LUKE YELLE	10:00 AM	B&L LOBBY
JONATHON ZDUNSKI	9:45 AM	B&L 106

XLI RSPS – ROCHESTER SYMPOSIUM FOR PHYSICS, ASTRONOMY AND OPTICS STUDENTS
SPS ZONE 2 REGIONAL MEETING

PROGRAM

8:00 AM – 8:30 AM: REGISTRATION AND POSTER SETUP (B&L LOBBY)

8:30 AM: WELCOME: BRAD CONRAD, AMERICAN INSTITUTE OF PHYSICS (B&L 109)

9:00 AM – 10:00 AM: SESSION IA. ASTRONOMY AND ASTROPHYSICS (B&L 109)

SESSION CHAIR: PROF. KA-WAH WONG, SUNY BROCKPORT

9:00 AM	**Extracting Source Redshifts from Spectroscopic Gravitational Lenses in DESI** Noah Franz and John Moustakas, Siena College
9:15 AM	**Classifying Solar Flares using Supervised Machine Learning** Nicole Hao and Laura Flagg, Cornell University
9:30 AM	**Simulating large scale structure as an effective pion fluid** Bart Horn and Bhavya Mishra, Manhattan College
9:45 AM	**Investigating the Physical Conditions of Emission-Line Galaxies using DESI Spectroscopy** Jacob Wunderlich, Siena College

9:00 AM – 10:00 AM: SESSION IB. INSTRUMENTATION & EXPERIMENTAL TECHNIQUES (B&L 106)

SESSION CHAIR: PROF. ZACHARY ROBINSON, SUNY BROCKPORT

9:00 AM	**Thin Metal Film Physical Vapor Deposition System** Matthew Bowman and Brandon Hoffman, Houghton University
9:15 AM	**Simulating Particle Transport within a Microcalorimeter to Unfold the Detector Response** Adam E. Brown, Houghton University
9:30 AM	**An Ambient Air Scanning Tunneling Microscope to Study the Surface of Thin Metal Films** Joshua Wilson and Brandon Hoffman, Houghton University
9:45 AM	**Using Phase Shift Interferometry to Measure the Topography of Thin Metal Films** Jonathon Zdunski, Houghton University

10:00AM – 11:00 AM: SESSION II. POSTER SESSION (B&L LOBBY)

Growth and Characterization of EuO/KTaO3 heterostructures
Mars Andersen, Kevin Euscher, Dr. Changjiang Liu, University at Buffalo

Calibration of Thomson Scattering for Applications in Pulsed Power
Aidan Bachmann and James Young, University of Rochester

NuSTAR Observation of the Gamma-Ray Emitting Radio Galaxy: NGC 315
Allison Blum, Ka-Wah Wong, Dacheng Lin, Jimmy Irwin and Rodrigo Nemmen, SUNY Brockport

Improving Low-cost Prosthetic Devices
Cam Brochu, St. Lawrence University

A Temperature Control Stage for Deposition of Thin Metal Films
Owen Fall, Luke Yelle and Brandon Hoffman, Houghton University

NuSTAR Observation of the Gamma-Ray Emitting Radio Galaxy: NGC 4261
Heather Flanagan and Dr. Kah-Wah Wong, SUNY Brockport

Depositing Lithium Films to Simulate ICF Reaction Products
Chunsun Lei, Andrew Hotchkiss, Andrew Martin, Adam Brown, Mark Yuly, James G. Mclean, Stephen J. Padalino, Chad J. Forrest, Thomas C. Sangster, and Sean P. Regan, Houghton University

An Experiment Simulating the Production, Capture, and Detection of 8Li from an ICF Implosion
Chunsun Lei, Andrew Hotchkiss, Andrew Martin, Adam Brown, Mark Yuly, James G. Mclean, Stephen J. Padalino, Chad J. Forrest, Thomas C. Sangster, and Sean P. Regan, Houghton University

Precision Calculations for Yukawa Coupling Strength Studies in Top-Quark Pair Production at the LHC
Thomas McEntire and Doreen Wackeroth, University at Buffalo

Testing the Detection Limits of Ground-based Surveys for Red Giant Asteroseismology
Jessica Nagasako, Daniel Hey, PhD and Daniel Huber, PhD, University of Rochester and University of Hawaii

Simulating Decay Energy Spectra Using Geant
Timothy R. Ockrin, Katrina E. Koehler and Ryan P. Fitzgerald, Houghton University

Exploring the Dark Sectors for New Forms of Matter and Millicharged Particles
Keopasith Phaphanthong and Doreen Wackeroth, University at Buffalo

NuSTAR Observation of the TeV-Detected Radio Galaxy: 3C 264
Colin Steiner, Ka-Wah Wong, Dacheng Lin, Jimmy Irwin and Rodrigo Nemmen, SUNY Brockport

Cosmic Ray Detector
Sean Theisen, Siena College

11:00 AM – 11:45 AM: SESSION IIIA. ASTRONOMY AND ASTROPHYSICS (B&L 109)

SESSION CHAIR: PROF. MICHAEL DUNHAM, SUNY FREDONIA

11:00 AM	**Exploring the sensitivity of next generation neutrino telescope at IceCube** Waly Karim and Yinqi Fang, University of Rochester
11:15 AM	**Instability Strips of 3 Types of Classical Variable Stars** Hugh Randall, A. Chalmers, N. Proietti, S. Kalici, M. Manno, S. Kanbur, E. Bellinger, M. Deka, S. Das, A. Bhardwaj, SUNY Oswego
11:30 AM	**Measuring Protostellar Luminosities Using Radiative Transfer Models** Zach Yek and Michael M. Dunham, SUNY Fredonia

11:00 AM – 11:45 AM: SESSION IIIB. NUCLEAR AND PARTICLE PHYSICS (B&L 106)

SESSION CHAIR: PROF. MARK YULY, HOUGHTON UNIVERSITY

11:00 AM	**Automatic Control of an Inertial Electrostatic Confinement Device** Micah K. Condie and Mark E. Yuly, Houghton University
11:15 AM	**Study Of Higgs Boson Processes At Fcc-Eh Collider** Shaib Sharhan, Manhattan College
11:30 AM	**Particle creation and energy conditions for a quantized scalar field in the presence of an external, time-dependent, Mamaev-Trunov potential** Issac Escapa, Henry Duggins, Doug Rennels and Keaton Detwiler, United States Military Academy

12:00 PM – 1:30 PM: LUNCH & PHYSICS CAREER TALK/WORKSHOP BY PROFESSOR MATTHEW WRIGHT, ADELPHI UNIVERSITY, SPS ZONE COUNCILOR (RUSH RHEES LIBRARY – HAWKINS-CARLSON ROOM)

1:45 PM – 3:00 PM: SESSION IVA. INSTRUMENTAL & EXPERIMENTAL TECHNIQUES / CONDENSED MATTER (B&L 109)

SESSION CHAIR: PROF. BRANDON HOFFMAN, HOUGHTON UNIVERSITY

1:45 PM	**Optical Properties of Niobium Oxide Films** Vincent Daviero, SUNY Brockport, SUNY Polytech
2:00 PM	**Building a Confocal Laser-Scanning Microscope and Writing GUI-Based Control Software for Biological Imaging and 2D Material Characterization Purposes** Miles D. Ackerman, Union College
2:15 PM	**Designing a Stage-Quality Spotlight** Brian Bauer, Siena College
2:30 PM	**Water Purification Using Iron Oxide Nanoparticles** Ryan O'Connor, SUNY Brockport
2:45 PM	**Crystallization Study of Ti-Doped NbO2 Thin Films** Katie Pittman, Zachary Robinson, Vincent Daviero, Karsten Beckmann, Nathaniel Cady and Matthew Sullivan, SUNY Brockport and SUNY Polytech

1:45 PM – 2:30 PM: SESSION IVB. ASTRONOMY, PARTICLE PHYSICS & QUANTUM OPTICS (B&L 106)

SESSION CHAIR: PROF. MICHAEL PFENNING, UNITED STATES MILITARY ACADEMY

1:45 PM	**Measuring Gravitational Time Dilation in a Balloon Satellite with Chip Scale Atomic Clocks** CDT Robert Collier, CDT Tim Godsil, CDT Sean Huh and CDT Bryce Corkery, United States Military Academy
2:00 PM	**Pressure Effects in a Portable Time Projection Chamber** Kale Sheets, United States Military Academy
2:15 PM	**4-level ladder electromagnetic induced transparency quantum antenna: experiment** S.C. Damonte, W.R. Kaiser, N.L. Segovia, K.A. Ingold, L.E. Harrell, D. O. Kashinski, and B.C. Holloway, United States Military Academy

SESSION IA. ASTRONOMY AND ASTROPHYSICS

Extracting Source Redshifts from Spectroscopic Gravitational Lenses in DESI

Noah Franz and John Moustakas, Siena College

Gravitational lensing occurs when the light from a distant background object is magnified by the mass of a foreground galaxy due to relativistic effects. In spectroscopic surveys, gravitational lenses can be discovered by identifying the features of both the foreground and background sources in a single spectrum. The Dark Energy Spectroscopic Instrument (DESI) is a five-year survey that will obtain spectra from more than 40 million galaxies. We analyze roughly 3,000 spectroscopic lenses of known gravitational lenses observed by DESI. We model the combined spectrum, subtract out the model, and perform a redshift fit on the residual spectrum. We present properties of the residual spectra and discuss prospects for future work.

Classifying Solar Flares using Supervised Machine Learning

Nicole Hao and Laura Flagg, Cornell University

Solar flares are intense bursts of radiation coming from the release of magnetic energy from the Sun. They are a crucial and well-studied aspect of solar magnetic activity, but automatically and accurately classifying them is still a challenge to researchers in astronomy. We present a standardized procedure to classify solar flares using supervised machine learning. Using a set of solar flares data from the NASA database and solar spectra from Data & Analysis Center for Exoplanets (DACE), we used supervised machine learning and found the best performing algorithm is a C-Support Vector Classification with non-linear kernels, specifically Radial Basis Function (RBF) or polynomial kernel. In order to optimize the performance of our model, we also determined the hyper-parameters to tune, such as polynomial degree and alpha value for SVC. The best trained model accurately classified weak (6-12 keV) and strong (greater than 6 - 12 keV) solar flares, and was also capable of distinguishing flares from disturbances. Testing the model showed that the model is able to detect and classify solar flares in completely new data with different characteristics and distributions from those of the training set.

Simulating large scale structure as an effective pion fluid
Bart Horn and Bhavya Mishra, Manhattan College

We discuss work in progress developing an efficient numerical simulation for the coupled partial differential equations of Large-Scale Structure in cosmology, by describing LSS in terms of an effective fluid description inspired by soft-pion theorems from high energy physics, and using adaptive mesh refinement and other methods to improve computation time and simulation efficiency.

Investigating the Physical Conditions of Emission-Line Galaxies using DESI Spectroscopy
Jacob Wunderlich, Siena College

This project utilizes data from the Dark Energy Spectroscopic Instrument (DESI) Survey to study the evolution of star-forming galaxies with a statistical sample across cosmic time. By systematically characterizing the physical properties of these galaxies, we aim to explore the relationship between these properties, the star formation rate and stellar mass of the population. Using the line flux of nebular emission lines produced by singly ionized oxygen [OII] 3729,26Å, we calculate electron densities to measure the pressure of the interstellar medium in a redshift range of ($0.6 < z < 1.6$). The project's findings suggest that the pressure of the interstellar medium is an important factor in regulating star formation in these galaxies. Moreover, the project's findings may contribute to the current astrophysical models of galaxy evolution and shed light on any unknown underlying effects.

SESSION IB. INSTRUMENTATION & EXPERIMENTAL TECHNIQUES

Thin Metal Film Physical Vapor Deposition System

Matthew Bowman and Brandon Hoffman, Houghton University

A low-cost, thin film deposition system utilizing physical vapor deposition is being constructed at Houghton University. A mechanical and turbomolecular pump lower the chamber to a base pressure of 10-6 Torr. Three graphite crucibles are heated via thermionic emission from three corresponding tungsten filaments. Each filament floats at up to -4 kV with individually controlled currents of up to 3 A. The use of three separate crucibles and filaments allows for the deposition of up to three different materials either simultaneously or sequentially. The 10 cm Si substrate onto which the metals are deposited is mounted on a rotatable feedthrough behind a stepper motor-controlled linear shutter, which provides a method for depositing with a thickness gradient. A Giedd and Perkins evaporation rate monitor allows controlled deposition. The chamber is currently capable of producing films and is being retrofitted to use an Arduino to control the deposition process more easily.

Simulating Particle Transport within a Microcalorimeter to Unfold the Detector Response

Adam E. Brown, Houghton University

The measurement technique of Decay Energy Spectroscopy (DES) utilizes high-energy resolution (7.5±0.2 eV FWHM at 6539 eV) [1] low temperature microcalorimeters to measure the total energy of a decay from an embedded radioactive source. DES spectra are histograms of the total decay energy thermalized in the absorber. Some of this energy is lost, largely due to decay products escaping the absorber or energy stored in metastable states (the latter depends on source preparation and is not considered in this work). This results in a measurement of energy that is lower than the decay energy. The escape probability is not constant as a function of initial decay energy but is dependent on the absorber material and the source's energy, type, location, and distribution—all of which form what we call the detector response. In this work, the response matrix for a microcalorimeter is built using EGSnrc—a Monte Carlo particle transport software—to simulate the energy deposition of a point source of monoenergetic beta particles ranging from 10 keV to 2 MeV. This response matrix may be used to deconvolve the detector response from a DES measurement so systematic uncertainty can be reduced. This will result in a more precisely known beta decay shape, important for fields such as nuclear medicine and testing theoretical descriptions of beta decay at low energies.

An Ambient Air Scanning Tunneling Microscope to Study the Surface of Thin Metal Films

Joshua Wilson and Brandon Hoffman, Houghton University

An ambient-air scanning tunneling microscope (STM) is being built at Houghton University to study the crystal growth and transformation of thin metal films. The STM operates by maintaining a constant current between a piezoelectrically-controlled scanning probe and the thin metal film sample while recording the height of the probe relative to the sample stage. This current is produced when electrons from the sample quantum tunnel through the ~10-10 m air gap to the probe, aided by a small bias voltage of ~-1 V applied to the sample; in order to achieve a tunneling gap of this size, the STM utilizes stepper motors to perform a rough approach of the probe to the sample. The STM is suspended on a dual-stage vibration isolation system which utilizes springs with eddy current damping to protect the STM from background noise. The STM is controlled by a user interface via the Processing IDE software and a Teensy 4.1 microcontroller via the Arduino IDE, along with a control circuit. The data collected by the STM are used to create an intensity plot that will act as an atomic resolution “image” of the film surface. All hardware, electronics, and programs have been completely and successfully tested.

Using Phase Shift Interferometry to Measure the Topography of Thin Metal Films

Jonathon Zdunski, Houghton University

A low-cost phase-shifting laser interferometer is being constructed at Houghton University to measure the thickness and topography of thin metal films produced with a variety of deposition parameters. The modified Twyman-Green Interferometer uses a 632 nm laser. Three piezoelectric ceramic stacks move a reference mirror up to 883 nm along the direction of the beam with a precision of <1 nm. The interference pattern is captured by a 2 MP camera. The system is suspended by springs and uses eddy current damping to decrease the movement of the system. A housing mounted to the outer frame blocks wind produced by the building’s air handling system. A LabVIEW program controls the mirror movement and fits a sine function to the intensity of each pixel vs. reference mirror position. An intensity plot of the fitted phase shifts represents the topography. Initial tests using two λ/10 flat mirrors indicate that the individual pixel height measurements are repeatable within about 1.6 nm. Assuming the film surface is smooth, the maximum repeatability of the overall topography should therefore be <1 nm.

SESSION II. POSTER SESSION

Growth and Characterization of EuO/KTaO3 heterostructures

Mars Andersen, Kevin Euscher and Dr. Changjiang Liu, University at Buffalo

In this study, we report on the growth and characterization of two dimensional electron gas (2DEG) at the EuO/KTaO3 interface. These heterostructures are created by growing an insulating EuO layer on KTaO3 (KTO) (111) and (110) substrates using molecular beam epitaxy (MBE). The goal for this study is to investigate how the charge carrier density of the 2DEG can be controlled through varying the growth conditions, as it has been reported that the superconductivity at these interfaces has a strong dependence on the charge carrier density. We use a high-purity Eu source and an absorption-limited growth method, where oxygen supply is the limiting factor to grow the EuO layer. We use transport measurement and Hall effect to determine the superconducting transition temperature and charge carrier density, respectively.
Our results suggest that the charge carrier density of the 2DEG at EuO/KTaO3 interface can be varied over a large range through the control of growth parameters. This provides opportunities for studying charge carrier density dependent physics such as superconductivity at these heterostructures.

Calibration of Thomson Scattering for Applications in Pulsed Power

Aidan Bachmann and James Young, University of Rochester

Thomson scattering is an essential diagnostic for the analysis of laboratory plasmas. As the low energy limit of Compton scattering, such a diagnostics allows the user to probe flow properties with minimal perturbations to the plasma. For the purposes of benchmarking, we analyze self-emission of a laser spark in air and perform temperature calculations through Thomson scattering and interferometry measurements.

NuSTAR Observation of the Gamma-Ray Emitting Radio Galaxy: NGC 315

Allison Blum, Ka-Wah Wong, Dacheng Lin, Jimmy Irwin and Rodrigo Nemmen, SUNY Brockport

Most of the active galactic nuclei (AGNs) in the local universe are low-luminosity AGN (LLAGNs). They are generally associated with radiatively inefficient accretion flows (RIAFs). We present our study of the gamma-ray emitting radio galaxy NGC 315 hosting a LLAGN with a misaligned jet. Multi-wavelength studies suggest that X-rays come from jets, however, it is also possible that the RIAF can contribute significantly to the X-rays. We present our study of the origin of the X-rays by using the NuSTAR X-ray Observatory. Using our X-ray data, we also provide constrains on the synchrotron self-Compton (SSC) model, which is believed to be the gamma-ray emitting mechanism for the LLAGN.

Improving Low-cost Prosthetic Devices

Cam Brochu, St. Lawrence University

This study aims to address the limitations of current prosthetic devices by developing a low-cost alternative with sensation capabilities such as temperature and touch. Our design mimics the human body's own response and builds upon the work of Osborn et al. by incorporating temperature feedback mechanisms, in addition to their pressure systems. The proposed design offers a more comprehensive sensory experience for prosthetic users, and provides sensation within the range of the human's body response. The circuit has been constructed using low-cost materials, resulting in a budget of $300, which is significantly cheaper than other expensive prosthetic alternatives.

A Temperature Control Stage for Deposition of Thin Metal Films
Owen Fall, Luke Yelle and Brandon Hoffman, Houghton University

Because the properties of the films are significantly affected by a deposition temperature change of only several degrees Celsius, it is vital that the substrate temperature be uniform across the entire substrate and constant throughout the deposition process, even while it is being radiatively heated by the evaporant metal. A temperature control substrate stage is being developed at Houghton University for thin metal films produced on 10 cm Si substrates via physical vapor deposition, with a base pressure of 10-6 Torr. To test possible substrate-stage adhesion materials, a test chamber was set up containing a substrate fixed to a 10 cm diameter aluminum heat sink. Resistive wire was epoxied to the substrate surface to simulate the ~6.5 W of radiative heating that would occur during deposition. Using double-sided copper tape, the minimum temperature change was 18°C in 10 minutes. Adding clamps decreased this to 13°C in 10 minutes. Using Ag paste as an adhesive resulted in a temperature change of only 3°C in 10 minutes.

NuSTAR Observation of the Gamma-Ray Emitting Radio Galaxy: NGC 4261
Heather Flanagan and Dr. Kah-Wah Wong, SUNY Brockport

At the center of a radio galaxy NGC 4261, there is a low-luminosity active galactic nucleus (LLAGN) resulting from the accretion of matter onto the supermassive black hole. It has been suggested that the X-rays of the LLAGN can be originated from either the accretion flow inwards or from a jet shooting outward. This remarkable relativistic jet has been observed in radio to gamma-ray bands. The most popular model of the overall emission is the synchrotron self-Compton model. Yet, the hard X-ray emission predicted by such model has not been verified. The detailed mechanism of how the high-energy X-ray and the gamma-ray emission that is produced is still unknown. The hard X-ray data collected by the NuSTAR Hard X-ray Observatory on this LLAGN was analyzed to gain a clearer understanding of the origin and nature of the emission. It was found that the soft (3-7keV) emission is extended, while the hard (15-20keV) emission is nearly point-like. For future work, further analysis of the NuSTAR and Swift spectra is needed to test whether the emission originates from the accretion flow, or from the relativistic jet.

Depositing Lithium Films to Simulate ICF Reaction Products

Chunsun Lei, Andrew Hotchkiss, Andrew Martin, Adam Brown, Mark Yuly, James G. Mclean, Stephen J. Padalino, Chad J. Forrest, Thomas C. Sangster, and Sean P. Regan, Houghton University

A possible future experiment using Inertial Confinement Fusion (ICF) to measure low-energy light-ion nuclear cross sections has been simulated using the SUNY Geneseo Pelletron to activate a thin lithium target which was then rapidly evaporated, trapped, and detected. This experiment required a lithium film to be deposited in a vacuum of approximately 10-5 Torr onto the surface of a thin tungsten foil. The films were produced by heating natural lithium pellets to 400 °C in a stainless-steel boat through which 20 A of current was passed. The evaporated lithium was contained inside a stainless-steel “house” inside the vacuum chamber, with a small opening on the top that allowed the lithium to reach the tungsten foil. The vacuum chamber was in an argon-filled glove bag which allowed the films to be briefly removed and handled since lithium reacts vigorously with oxygen and water vapor.

An Experiment Simulating the Production, Capture, and Detection of 8Li from an ICF Implosion

Chunsun Lei, Andrew Hotchkiss, Andrew Martin, Adam Brown, Mark Yuly, James G. Mclean, Stephen J. Padalino, Chad J. Forrest, Thomas C. Sangster, and Sean P. Regan, Houghton University

Inertial confinement fusion (ICF) is a possible tool for measuring light-ion nuclear cross sections. One way to do this might be to trap and detect the radioactive decays of the product nuclei produced using a doped target capsule. Some of the highest yield light-ion reactions that could be studied using this technique are 6Li(t,p) 8Li and 9Be(t,α) 8Li, both of which produce 8Li. In order to simulate this method, a natural lithium film was deposited onto a tungsten substrate, which was then activated via the 7Li(d,p) 8Li reaction using the SUNY Geneseo Pelletron accelerator. A current pulse of up to 1000 A was discharged through the tungsten raising its temperature to as high as about 1500 °C in less than a few milliseconds, causing the lithium to rapidly evaporate and produce a gas of neutral lithium atoms which then travelled outward and stuck to the aluminum getter detector foil of the Short-Lived Isotope Counting System (SLICS). This phoswich detector was used to identify beta particles and count in situ the 840 ms beta decay curve for 8Li as a function of time in order to estimate the efficiency of SLICS for trapping and detecting ICF reaction products. Funded in part by a grant from the DOE through the Laboratory for Laser Energetics, and by SUNY Geneseo and Houghton University.

Precision Calculations for Yukawa Coupling Strength Studies in Top-Quark Pair Production at the LHC

Thomas McEntire and Doreen Wackeroth, University at Buffalo

A look at how the strength of the top-quark Yukawa coupling affects top-quark pair production at the CERN Large Hadron Collider (LHC) is presented. We utilize the program HATHOR to calculate the complete cross sections for the processes of qq -> tt~ and gg -> tt~, incorporating multi-loops calculations within the context of Quantum Chromodynamics (QCD). One-loop electroweak (EW) corrections which introduce sensitivity to the Higgs sector of the Standard Model (SM) are also considered. We examine the impact of higher-order corrections on collision results to enhance the accuracy of our findings. By improving the precision of our cross-section calculations, we increase the probability of identifying discrepancies with current predictions within the framework of the SM.

Testing the Detection Limits of Ground-based Surveys for Red Giant Asteroseismology

Jessica Nagasako, Daniel Hey, PhD and Daniel Huber, PhD, University of Rochester

Asteroseismology, the study of stars exhibiting stellar-like oscillations, has revolutionized the understanding of stars. Several classes of oscillating stars are powerful distance indicators but the effectiveness of ground-based data for detecting oscillations in M-giants as a distance indicator is not yet well understood. Less luminous stars oscillate with lower amplitudes and higher frequencies, and previous studies have suggested that ground-based transient surveys are limited to stars oscillating with frequencies below 1μHz (10-day periods). To quantify this detection limit, we selected a sample of red giants from the All-Sky Automated Survey for Supernovae (ASAS-SN) based on a well-characterized catalog of Kepler stars with known oscillation frequencies in which we know the ground truth. After we selected stars in between 0.1 and 2μHz maximum frequency (νmax) and analyzed light curves from ASAS-SN, we were left with 98 stars for our data selection. We detected oscillations above 1μHz for eight stars, demonstrating that ground-based surveys can detect oscillations in lower luminosity stars. Future work will determine the detection limits as a function of frequency and apparent magnitude, which will quantify the selection function of asteroseismic distance catalogs derived from ground-based surveys.

Simulating Decay Energy Spectra Using Geant4

Timothy R. Ockrin, Katrina E. Koehler and Ryan P. Fitzgerald, Houghton University

Decay Energy Spectroscopy (DES) uses high energy resolution (~1 keV FWHM at 5 MeV [1]) microcalorimeters to measure the total energy of each decay from an embedded radioactive source. A histogram of these energies enables the determination of radionuclide composition, useful for both nuclear safeguards and metrology. In some fraction of decays, some of the decay energy is not thermalized when a particle such as a gamma ray, X-ray, or electron escapes the detector. The probability of this happening depends on the location of the parent nucleus in the absorber, the types and energies of particles released in the decay, and the material, size, and shape of the absorber. A library of possible spectra is created by simulating different shapes and sizes of detector absorbers and compositions, locations, and distributions of sources using the Monte-Carlo particle simulation software Geant4. With Decay Energy Spectroscopy SIMulation for Absolute Total Efficiency (DESSIMATE), a python graphical user interface for visualization, an experimental spectrum can be expressed as a linear combination of these simulated spectra. This will allow the total activity of each radionuclide in a measured sample to be determined. This method can potentially be used in the certification of Standard Reference Materials (SRMs) with precisely known massic activities (defined as unit activity per unit mass).

Exploring the Dark Sectors for New Forms of Matter and Millicharged Particles

Keopasith Phaphanthong and Doreen Wackeroth, University at Buffalo

The Standard Model (SM) of particle physics describes our current understanding of three of the four known fundamental forces in the universe, electromagnetic, weak and strong forces, though it isn’t complete. Currently, gravity is not explained in the SM. Alongside gravity, there are many other questions that require answers, such as Dark Matter. The presence of Dark Matter in the universe motivates the study of extensions to the SM called the Dark Sector. This sector may contain new forms of matter and new forces. Among them, millicharged particles (mCP) may appear, these are particles, which carry a small fraction of the electric charge of the electron. The observation of such particles would be a major paradigm shift. In this study we will discuss the theoretical framework and will obtain predictions for possibly observable experimental signatures of mCPs.

NuSTAR Observation of the TeV-Detected Radio Galaxy: 3C 264

Colin Steiner, Ka-Wah Wong, Dacheng Lin, Jimmy Irwin and Rodrigo Nemmen, SUNY Brockport

The origin of X-ray emission from low-luminosity active galactic nuclei (LLAGNs) are not very well understood. It has been suggested that the X-rays can come from either the accretion flow toward the central supermassive black holes or from the relativistic jets of these systems. We present results on our NuSTAR hard X-ray observation on the LLAGN 3C 264 to study the nature and origin of its X-ray emission. 3C 264 is also one of the few FRI radio galaxies detected with very high energy (VHE) TeV emission. The origin of such VHE emission is still unclear. The most popular model of such high energy emission is the synchrotron self-Compton model. With our NuSTAR hard X-ray observation, we will report constraints on the VHE emission mechanisms.

Cosmic Ray Detector

Sean Theisen, Siena College

Using MIT's CosmicWatch Design, I constructed a cosmic ray detector with the intent of detecting the flux of muons through Earth's atmosphere. These muons are high-energy particles that bombard Earth's surface and can be detected by using a scintillator and a silicon photomultiplier tube. Muon detection is a difficult process because these particles are able to pass through materials without interaction, but when passing through scintillators they produce a small amount of light when they absorb particles creating photons that can then be absorbed into the photomultiplier tube creating a signal. Using this concept I can place the detector at different altitudes and angles to see how that varies the rate. Adding a second muon detector in conjunction with the first allows for more accurate data as it is able to cancel out a large portion of the noise by running the two detectors in coincidence mode. The data collected was analyzed using statistical methods to determine the muon flux and to compare it with theoretical predictions. The current results and status of this project will be presented.

SESSION IIIA. ASTRONOMY AND ASTROPHYSICS

Exploring the sensitivity of next generation neutrino telescope at IceCube

Waly Karim and Yinqi Fang, University of Rochester

The IceCube Neutrino Observatory is capable of detecting high-energy astrophysical neutrinos from unknown sources as well as bursts of MeV neutrinos produced by galactic core-collapse supernovae (CCSNe). The next-generation telescope, IceCube Gen2, will encompass nearly ten times the volume as IceCube, and will use new digital optical modules (DOMs) currently being developed and tested. The design of the new modules will have a significant impact on the sensitivity of IceCube-Gen2 to supernova neutrinos. To estimate the sensitivity and optimize the sensor design, we compared the detection efficiencies of different Gen2 DOM models. We achieved this by developing a high-fidelity mono-energetic positron injection simulation in GEANT4 to simulate the bulk-ice environment and sensitive surfaces of different DOM designs being considered for use in Gen2. The simulations give insight into the performance of the new DOM designs, and can be used to optimize Gen2 to be more sensitive to CCSNe MeV neutrino bursts.

Instability Strips of 3 Types of Classical Variable Stars

Hugh Randall, A. Chalmers, N. Proietti, S. Kalici, M. Manno, S. Kanbur, E. Bellinger, M. Deka, S. Das and A. Bhardwaj, SUNY Oswego

This project uses the 1D hydrodynamic radiation code MESA/RSP with four different theories of convection to model pulsating stars. Theoretical instability strips are determined from these models and compared to observational data from the OGLE IV mission. The comparison can be used to constrain the current theory of stellar pulsation.

Measuring Protostellar Luminosities Using Radiative Transfer Models

Zach Yek and Michael M. Dunham, SUNY at Fredonia

Studying internal luminosities, \$L_\text{int}\$, of embedded, low-luminosity protostars has traditionally required multi-wavelength observations, which can be both time and resource intensive. Dunham et. al. (2008) uncovered a critical wavelength at 70 microns where the flux values, \$F_\text{70}\$, were linearly correlated with \$L_\text{int}\$. However, this correlation was only derived for Class 0 protostars. We present our findings from simulating embedded, low-luminosity systems using radiative transfer modeling, where we determined that the derived 70 micron correlation remains robust even for Class I protostars. Additionally, we find that the data at 100 microns yield a marginally better fit, with lower model variance.

SESSION IIIB. NUCLEAR AND PARTICLE PHYSICS

Automatic Control of an Inertial Electrostatic Confinement Device

Micah K. Condie and Mark E. Yuly, Houghton University

The Houghton University Farnsworth-Hirsch fusor is an inertial electrostatic confinement device designed for the purpose of studying plasmas, D-D fusion, and as a source of x-rays and neutrons for other experiments. It operates via two concentrically arranged wire spheres with a voltage difference between them of up to 30 kV, ionizing a low-pressure gas to form and confine a plasma. The voltage across the two spheres is measured using a voltage divider circuit allowing the Arduino at the bottom of the chain to measure a lower proportional voltage. The current to the HV grid flows through an LED, floating at high voltage, the light from which is then measured at the end of a fiber optic cable using a phototransistor circuit. The previous fusor remote operating system used LabVIEW and Digi TS4 Port servers to communicate with the high voltage power supply, pressure gauge, and mass-flow controller via ethernet, RS-232, and RS-485. It was redesigned using python to communicate with the instrumentation directly over USB and RS-485. Furthermore, a PID controller was made so that the pressure in the chamber could be adjusted automatically, maintaining the plasma while raising the voltage. The fusor was successfully tested using air as the ionized gas with limited success using the PID controller. Future experiments will correct the automatic system and test the system with hydrogen then deuterium.

Study Of Higgs Boson Processes At Fcc-Eh Collider

Shaib Sharhan, Manhattan College

The Future-Circular Collider (FCC) is a future project that will be created to observe the effects of higher energy polarized collisions of different particles, which has never been done before. Using MadGraph simulations of Monte Carlo event-generated techniques, I was able to simulate FCC-eh particle collisions. Simulations were created for proton-electron collisions with charge currents (CC), containing W bosons, and neutral currents (NC), containing Z bosons. The number of events was then calculated for CC and NC collisions including and excluding decays, with -80 polarization and without. The Standard Model (SM) and Beyond the Standard Model (BSM) were then compared using couplings cHW, cHB, and cHWB. Different graphs were constructed using Anaconda to analyze the different parameters created by the BSM.

Particle creation and energy conditions for a quantized scalar field in the presence of an external, time-dependent, Mamaev-Trunov potential

Issac Escapa, Henry Duggins, Doug Rennels and Keaton Detwiler, United States Military Academy

In 2011-2012, Dan Solomon published two papers in the journal Advanced Studies in Theoretical Physics in which he describes examples of violations of the spatial and temporal quantum inequalities. The model Solomon was studying was a quantum field theory which obeys the Klein-Gordon-Fock wave equation in two-dimensional Minkowski spacetime with the field coupled to a time-dependent, Mamaev-Trunov-type potential. Solomon's approach is mostly correct, but he carries out his derivation using incomplete Cauchy data to determine the future evolution of the stress-energy tensor. Therefore, his conclusions about the violations of the quantum inequalities are incorrect.

In 2018, Michael Pfenning published a paper studying the same quantum field theory on a two-dimensional, spatially-closed spacetime. Using complete Cauchy data, he showed that the quantum inequalities are not violated. In fact, the piece of missing Cauchy data in Solomon's model gives rise to a sufficiently large positive energy flux to ensure the quantum inequalities hold.

Our research project is to reproduce the calculations of Solomon's model using Pfenning's technique for calculating the missing Cauchy data. The first step in this process is to determine the evolution of the modes of the quantum field theory. All of the models have the Mamaev-Trunov-type potential turned on for times $t < 0$, and it is instantaneously switched off at time $t=0$. We use the past mode solutions and their time derivatives at time $t=0$ as the Cauchy data to determine for the future evolution of the wave. Our presentation will discuss our work up to this date in deriving the solutions to the wave equation for times $t>0$. Future work would include determining the stress-energy tensor for the quantum field in the $t>0$ portion of the spacetime and checking to see that it does obey the quantum inequalities.

SESSION IVA. INSTRUMENTAL & EXPERIMENTAL TECHNIQUES / CONDENSED MATTER

Optical Properties of Niobium Oxide Films

Vincent Daviero, SUNY Brockport

Complimentary metal-oxide-semiconductor (CMOS) devices, such as diodes and transistors, are used to create integrated circuits for computer technology. Over the last few decades, advancements in computers have primarily come from shrining the size of transistors so that more can be incorporated in a computer chip. However, the devices are quickly approaching their fundamental limit. CMOS-compatible devices that can mimic the electrical properties of neurons provide an opportunity to advance past this limit. A neuron's electrical behavior is characterized by switching from an insulator to a conductor to propagate signals. The development of neuron-like CMOS devices could be the first step towards making neuromorphic computational devices. A material that shows promise due to its electrical similarities to neurons is niobium dioxide (NbO2). Currently the temperature that NbO2 switches from insulator to conductor is too high for incorporation into a circuit. Research is being conducted on ways to lower this temperature with different deposition techniques, as well as modify the switching temperatures. My research project was focused on developing an instrument that could measure the optical properties of NbO2 so that the transition temperature of the films could be determined.

Building a Confocal Laser-Scanning Microscope and Writing GUI-Based Control Software for Biological Imaging and 2D Material Characterization Purposes

Miles D. Ackerman, Union College

We implement, from scratch a confocal laser-scanning microscope (CLSM) system applicable for Physics & Biology related projects ranging from the characterization and modulation of 2D material-based devices to in-vivo imaging of cellular structures and 3D sample reconstruction. Scanning microscopy offers several advantages over traditional wide-field fluorescence microscopy including: increased image resolution via the elimination of out-of-focus secondary fluorescence, the ability to resolve thick samples through a series of optical sections, and localized excitation. The device is built from readily available commercial products and implements multiple laser wavelengths, a 3-axis computer-controlled sample stage, broadband illumination, and spectroscopy capabilities. We provide an open-source, custom Python GUI-based software package written using the National Instruments API (NI-DAQmx) and additional ThorLabs driver-specific APIs. This system is capable of acquiring images in all coordinate planes of both biological and solid-state systems and provides opportunities for localized PL characterization, tiling, and other imaging methods.

Designing a Stage-Quality Spotlight

Brian Bauer, Siena College

Spotlights are used in many industries, yet are most important in the theater industry. Accurately lighting the stage and the performers according to the direction of a lighting designer is made possible through the use of many different types of spotlights. Ellipsoidal reflector spotlights (ERS) are one of these such devices that have been used for a long time. Using a high intensity light source reflecting off of an ellipsoidal mirror to focus the light onto a lens, an ERS is capable of providing a well lit environment for a performance from a great distance away. I have been working with Zemax OpticStudio in an effort to design an ERS from scratch in order to learn about optics and become familiar with the tools commonly used. The goal was to create a design that performs similarly to a real one. Using experimentally collected data I compare my design against a Source-4 spotlight.

Water Purification Using Iron Oxide Nanoparticles

Ryan O'Connor, SUNY Brockport

When it comes to water purification, one of the most widespread methods of eliminating bacteria and microbes, chlorination, involves adding chlorine to water to disinfect. However, chlorine, at the commonly used concentrations, can cause irritation to the human body, and certain by-products of the procedure are carcinogens that can have lasting effects. In this study we looked to synthesize iron oxide nanoparticles (magnetite, or Fe_3O_4) for the eventual use in wastewater purification applications. In principle, these magnetic particles can be used to remove a variety of impurities, and they should be reusable, as they can be removed using a magnet and cleaned for use in future processes. To create the iron oxide nanoparticles we used three different procedures: chemical co-precipitation, in which we explored both a standard method as well as ‘green’ synthesis procedures; thermal decomposition; and electrochemical synthesis. On top of testing the efficacy and ease each procedure shows when creating the particles, we also wanted to compare the overall quality of the particles synthesized by each method. Lastly, we wanted to explore how changing certain parameters, like reaction time and amount of chemicals used in a procedure, impacts the size, shape, and electrostatic properties of the particles.

Crystallization Study of Ti-Doped NbO2 Thin Films

Katie Pittman, Zachary Robinson, Vincent Daviero, Karsten Beckmann, Nathaniel Cady and Matthew Sullivan, SUNY Brockport

The purpose of my research this summer was to take niobium dioxide thin films, and crystallize them. The films were deposited on silicon wafers by physical vapor deposition and atomic layer deposition, both of which are amorphous as-deposited. In addition to comparing the different deposition techniques, we also studied 2 Ti-doped NbOx films. The properties in NbO2 crystalline form have applications in electrical switching and memory devices. In order to crystalize the samples, they were placed in a tube furnace and annealed at different times, temperatures, and using different gasses. Once the samples were annealed, the crystallization percentage was measured. Atomic force microscopy (AFM) was used to compare the topography between the as-deposited and crystallized samples. I was able to conclude that around 825°C is when NbO2 transitions from amorphous to crystalline. Ultimately, this research may help improve the efficiency of computers and computational devices.

SESSION IVB. ASTRONOMY, PARTICLE PHYSICS & QUANTUM OPTICS

Measuring Gravitational Time Dilation in a Balloon Satellite with Chip Scale Atomic Clocks

CDT Robert Collier, CDT Tim Godsil, CDT Sean Huh and CDT Bryce Corkery, United States Military Academy

Pressure Effects in a Portable Time Projection Chamber

Kale Sheets, United States Military Academy

Being able to detect radioactive sources effectively strengthens safety and security. Current radiation detection devices are limited in their capabilities and need to be improved upon to ensure fast, accurate localization and characterization of radioactive sources. One future method of radiation detection is a Portable Time Projection Chamber (TPC). A TPC is a gas-filled fast neutron radiation detector. Traditional neutron detectors undergo a loss of information when triggered. A TPC is extremely useful because its preserves energy, direction, and momentum information when triggered. Making a TPC portable allows for rapid development of the technology, decreasing exposure and allowing for a quick characterization and localization of the radioactive source. When making a condensed version of TPC, there is need for optimal chamber pressure and composition effects to ensure the results do not significantly diminish as the size of the chamber decreases. In this study, I manipulated the TPC gas pressure and composition and measured the light intensity. The higher the light intensity, the more effective the TPC will be since more incident neutrons can be detected. The results of this study enhance the ability to detect and localize radiation sources and improve nuclear security through applications of the TPC to rapidly detect life-threatening radiation sources.

4-level ladder electromagnetic induced transparency quantum antenna: experiment

S. C. Damonte, W. R. Kaiser, N. L. Segovia, K. A. Ingold, L. E. Harrell, D. O. Kashinski, and B. C. Holloway, United States Military Academy

Quantum Information Science & Technologies (QIST) is a topic of national priority. QIST has the potential to enable a new generation of transformative sensors similar to the transformative impact that the Global Positioning System (GPS), nuclear spin control for magnetic resonance imaging (MRI) and atomic clocks had last century. Researchers in the Photonics Researcher Center's Atomic, Molecular, and Optical Physics program (PRC-AMO) at the United States Military Academy (USMA) are working to establish an education-centered research-grade QIST laboratory with an initial focus on Quantum Sensors. This presentation outlines our preliminary efforts towards building an operational Rydberg-atom based Radio Frequency (RF) antenna capable of SI E-field meteorology.

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