University of Rochester, April 20, 2024

Dear Participants:

Welcome to the 42nd 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/2024/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 "Online 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, Department of Chemistry, Department of Electrical and Computer Engineering and the Institute of Optics are jointly running four 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.”

**Kelly A. Douglass (Chair RSPS)**
**Department of Physics and Astronomy**
**University of Rochester**

## LIST OF SPEAKERS

| PRESENTER | TIME | ROOM |
|---|---|---|
| ALLISON BLUM | 11:00 AM | B&L 106 |
| RICHARD CASEY | 11:15 AM | B&L 106 |
| ADAM CHOUDHRY | 10:00 AM | B&L LOBBY |
| NALIN COOPER-SHERROW | 10:00 AM | B&L LOBBY |
| DELANEY CUMMINS | 9:30 AM | B&L 106 |
| RAFAEL DE FARIAS | 10:00 AM | B&L LOBBY |
| OWEN FALL | 10:00 AM | B&L LOBBY |
| AVERY GILSON | 2:00 PM | B&L 106 |
| KYLIE GOLDADE | 10:00 AM | B&L LOBBY |
| MIMI HARRISON | 10:00 AM | B&L LOBBY |
| ANDREW HOTCHKISS | 9:00 AM | B&L 109 |
| PRINCE AZIZ HUNT | 10:00 AM | B&L LOBBY |
| WALY M Z KARIM | 9:00 AM | B&L 106 |
| LEVI KENNEL | 9:15 AM | B&L 109 |
| MASROOR KHONKHODZHAEV | 10:00 AM | B&L LOBBY |
| SEAN LANNON | 2:00 PM | B&L 109 |
| JULIA LARGETT | 9:15 AM | B&L 106 |
| CHUNSUN LEI | 2:15 PM | B&L 109 |
| ANNIE MALONEY | 10:00 AM | B&L LOBBY |
| ANDREW MARTIN | 11:00 AM | B&L 109 |
| AMII MATAMOROS DELGADO | 2:15 PM | B&L 106 |
| ALEX MAVIAN | 2:30 PM | B&L 106 |
| TOM MCENTIRE | 11:15 AM | B&L 109 |
| BHAVYA MISHRA | 11:30 AM | B&L 106 |
| JESSICA NAGASAKO | 10:00 AM | B&L LOBBY |
| TIMOTHY OCKRIN | 9:30 AM | B&L 109 |
| EMMA SARGENT | 2:30 PM | B&L 109 |
| SHALIB SHARHAN | 11:30 AM | B&L 109 |
| LARA STROUD | 10:00 AM | B&L LOBBY |
| DECLAN WALDEN | 10:00 AM | B&L LOBBY |
| COREY YOUNG | 10:00 AM | B&L LOBBY |

**XLII 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: KELLY DOUGLASS, UNIVERSITY OF ROCHESTER (B&L 109)**

**9:00 AM – 10:00 AM: SESSION IA. NUCLEAR AND PARTICLE PHYSICS (B&L 109)**

**SESSION CHAIR: PROF. MARK YULY, HOUGHTON UNIVERSITY**

9:00 AM **Design and Simulation of Strong-focusing Pole Tips for the Houghton University Cyclotron**
Andrew Hotchkiss, Houghton University

9:15 AM **A Parity Violation Transmission Experiment for Undergraduate Laboratories**
Levi Kennel, Houghton University

9:30 AM **The Effects of Radiation Escape on Accuracy and Precision in Isotopic Composition Determination of Uranium and Plutonium Samples with Decay Energy Spectroscopy**
Timothy Ockrin, Houghton University

**9:00 AM – 10:00 AM: SESSION IB. ASTRONOMY AND ASTROPHYSICS (B&L 106)**

**SESSION CHAIR: PROF. SHETH NYIBULE, UNIVERSITY OF ROCHESTER**

9:00 AM **Simulation-Based Optimization of IceCube-Gen2 Modules for Enhanced Sensitivity to Neutrinos from Galactic Core-Collapse Supernovae**
Waly M Z Karim, University of Rochester

9:15 AM **SGA Galaxy Morphology Classifier**
Julia Largett, University of Rochester

9:30 AM **Searching for Strong Gravitational Lenses in DESI Spectra**
Delaney Cummins, University of Rochester

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

**Development of Using Solar Renewable Energy in our Daily Lives**
Adam Choudhry, St. John's University

**Machine learning enhanced Quantum light detection**
Nalin Cooper-Sherrow, SUNY Buffalo

**Analyzing Cryogenic Implosion Data**
Rafael de Farias, University of Rochester

**A Temperature Control Stage for the Deposition of Thin Metal Films**
Owen Fall, Houghton University

**Social Outreach through Adelphi University's Physics Department**
Kylie Goldade, Adelphi University

**Identifying Massive Quiescent Galaxies with COSMOS-Web: The JWST Cosmic Origins Survey**
Mimi Harrison, Rochester Institute of Technology

**Validating Mass-Loss Measurements in Newly Forming Young Stars**
Prince Aziz Hunt, SUNY Fredonia

**Persistence of Correlations in Neurotransmitter Transport Through the Synaptic Cleft**
Masroor Khonkhodzhaev, CUNY Queens College

**Investigating Radiative Levitation in White Dwarf Stars by Large-Scale Molecular Dynamics Simulations**
Annie Maloney, University of Rochester

**Using Social Network Analysis to Understand Community Within an Introductory Physics Course**
Jessica Nagasako, University of Rochester

**Decomposing MaNGA Galactic Rotation Curves to Model Dark Matter Halos**
Lara Stroud, University of Rochester

**Measurement of Water Diffusion Coefficient in Cross-Linked Gelatins Using the Terahertz Time-Domain Spectroscopy Technique**
Declan Walden, University of Rochester

**Sequence heuristics to program nucleic acid phase separation**
Corey Young, SUNY Buffalo

**11:00 AM – 12:00 PM: SESSION IIIA. NUCLEAR & PARTICLE PHYSICS (B&L 109)**

**SESSION CHAIR: PROF. KATRINA KOEHLER, HOUGHTON UNIVERSITY**

11:00 AM **Target Normal Sheath Acceleration as a Technique for Measuring Nuclear Cross-Sections**
Andrew Martin, Houghton University

11:15 AM **Error-resilient quantum simulations with pulse-based techniques in the Schwinger model**
Tom McEntire, University at Buffalo

11:30 AM **Refining Straw Detector Capabilities for DUNE Experiment**
Shab Sharhan, Manhattan College

**11:00 AM – 12:00 PM: SESSION IIIB. ASTRONOMY & ASTROPHYSICS (B&L 106)**

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

11:00 AM **X-ray Observation of the Gamma-Ray Emitting Radio Galaxy: NGC 315**
Allison Blum, SUNY Brockport

11:15 AM **Scalar Field Limits for a Dark Big Bang**
Richard Casey, Colgate University

11:30 AM **Pion Lagrangian for large-scale-structure in cosmology**
Bhavya Mishra, Manhattan College

**12:00 PM – 1:45 PM: LUNCH & PHYSICS CAREER TALK/WORKSHOP**
**PROF. MATTHEW WRIGHT (RUSH RHEES LIBRARY – HAWKINS-CARLSON ROOM)**

**2:00 PM – 2:45 PM: SESSION IVA. INSTRUMENTAL / EXPERIMENTAL TECHNIQUES (B&L 109)**

**SESSION CHAIR: PROF. KRISTEN REPA, SUNY BROCKPORT**

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|---|---|
| 2:00 PM | **Studying the Properties of Niobium Oxide**<br>Sean Lannon, SUNY Brockport |
| 2:15 PM | **Deposition System for Thin Lithium Nuclear Targets**<br>Chunsun Lei, Houghton University |
| 2:30 PM | **Crystallization and Resistivity of Niobium Oxide Samples**<br>Emma Sargent, SUNY Brockport |

**2:00 PM – 2:45 PM: SESSION IVB. CONDENSED MATTER / NUCLEAR PHYSICS / INSTRUMENTATION / EXPERIMENTAL TECHNIQUES (B&L 106)**

**SESSION CHAIR: PROF. BEN OVRYN, NEW YORK INSTITUTE OF TECHNOLOGY**

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|---|---|
| 2:00 PM | **Phase Measuring Laser Feedback Interferometry with PID Control**<br>Avery Gilson, New York Institute of Technology |
| 2:15 PM | **Parameterizations of electron scattering form factors for elastic scattering and electron-excitation of nuclear states for 27 Al**<br>Amii Matamoros Delgado, University of Rochester |
| 2:30 PM | **Targeted Enhancement of Second Harmonic Generation in Layered Transition Metal Dichalcogenides using Structured Light**<br>Alex Mavian, Rensselaer Polytechnic Institute |

## SESSION IA. NUCLEAR AND PARTICLE PHYSICS

### Design and Simulation of Strong-focusing Pole Tips for the Houghton University Cyclotron

Andrew Hotchkiss and Mark Yuly, Houghton University

The Houghton University cyclotron accelerates ions inside of a 17 cm inner diameter evacuated aluminum chamber placed between the poles of a 1.2 T electromagnet. Two hollow “dee” electrodes, one grounded and one oscillating between a positive and negative potential, apply an electric force that with the magnetic field, accelerates the ions. Previously, weak magnetic focusing, which requires the magnetic field to decrease with larger radius, was used to force the ions back toward the central plane between dees. For large numbers of orbits, however, this made the ions get out of phase with the oscillating electric field. Strong focusing can fix this problem by creating a restoring force while keeping the cyclotron frequency the same. Mathematica and Radia, a 3D magnetic field modeling software package, were used to model the magnetic field of a strong-focusing sector pole tip, then calculate resulting ion orbits. In simulations, the original weak focusing pole tips allowed an ion orbit radius of 3.7 cm to be reached. Using newly designed strong focusing pole tips a radius of 4.9 cm corresponding to 165 keV for protons was achieved. The maximum radius theoretically achievable is 7.2 cm resulting in 360 keV of proton energy.

### A Parity Violation Transmission Experiment for Undergraduate Laboratories

Levi Kennel and Mark Yuly, Houghton University

Because there are currently no published weak interaction parity violation experiments specifically for undergraduate laboratories, a simple parity violation experiment is being developed using circularly polarized gamma rays. A 60Co source will be placed on one side of an electromagnet, so that the circularly polarized gamma rays emitted opposite the beta particles will pass through the electromagnet core. A NaI detector detects the number of gamma rays that pass through the electromagnet, and a silicon detector detects beta particles opposite the gamma rays. The number of coincidence events will be measured when the electromagnet is polarized both parallel and antiparallel to the gamma rays – an asymmetry between the number of coincidence events for each orientation would show that parity is violated.

**The Effects of Radiation Escape on Accuracy and Precision in Isotopic Composition Determination of Uranium and Plutonium Samples with Decay Energy Spectroscopy**

Timothy Ockrin and Katrina Koehler, Houghton University

Decay Energy Spectroscopy (DES) results in high energy resolution (1-5 keV @ 5 MeV) spectra of decay energies where the energy of each decay is measured as a single event as opposed to individual measurements of each decay particle. In order to accomplish this, the measured source is not external to the absorber, but embedded within it. DES can be used for nuclear safeguards, metrology, and medical isotope development, but measurements are affected by incomplete energy capture occurring when decay particles escape the absorber. In order to reduce escape likelihood, absorbers can be capped with a layer of gold. Geant4, a Monte-Carlo simulation software capable of handling energy transport between particles, is used to simulate DES measurements with varying thicknesses of absorber cap. Analysis of these spectra shows that the biggest benefit of capping can be realized by adding 5 µm of gold to all dimensions, reducing the escape of most alpha-decaying uranium and plutonium radionuclides by an order of magnitude.

## SESSION IB. ASTRONOMY AND ASTROPHYSICS

### Simulation-Based Optimization of IceCube-Gen2 Modules for Enhanced Sensitivity to Neutrinos from Galactic Core-Collapse Supernovae

Waly M Z Karim and Segev BenZvi, University of Rochester

The IceCube Neutrino Observatory is capable of detecting high-energy astrophysical neutrinos as well as bursts of MeV neutrinos from core-collapse supernovae (CCSNe). The IceCube-Gen2 will encompass nearly tenfold the volume of its predecessor, incorporating cutting-edge multi-PMT Digital Optical Modules (mDOMs) and Wavelength-shifting Optical Modules (WOMs) presently undergoing development and testing. The design of the new modules will have a significant impact on the sensitivity of IceCube to supernova neutrinos. To gauge sensitivity and refine sensor design, we devised a high-fidelity simulation in GEANT4, focusing on mDOMs and WOMs, accounting for depth-dependent ice properties enveloping the modules. The simulation allows for the direct injection of signal events, encompassing supernova neutrino flux with varying progenitor masses, as well as background events stemming from the radioactive decay of trace elements. Leveraging the mDOM simulation, we studied local coincidence in detected neutrinos and used "coincidence cuts" to attenuate background events and minimize the false detection rate of galactic CCSNe. Additionally, the WOM simulation yielded promising results by shifting Cherenkov radiation from the UV to the visible range, where the detectors exhibit peak sensitivity. Consequently, we anticipate WOMs to be more sensitive to supernova neutrinos compared to existing detectors in IceCube. These simulations can play a pivotal role in the optimization of neutrino detectors in IceCube-Gen2, enhancing their sensitivity to MeV neutrino bursts from CCSNe.

### SGA Galaxy Morphology Classifier

Julia Largett, Segev BenZvi and Kelly Douglass, University of Rochester

The Hubble sequence broadly classifies galaxies into three main types: elliptical, spiral, and lenticular galaxies. This system was developed primarily for nearby, luminous galaxies, resulting in a struggle to accommodate the increased number of observed galaxies due to modern telescopes. To optimize classification attempts, we are developing quantitative measures based on photometric properties that correlate with galaxy morphology: the concentration index (C), the Gini parameter (G), the asymmetry parameter (A), the second moment of light (M20), the multiplicity parameter (Ψ), and color bands (g, r, and z). By classifying galaxies with a Random Forest machine learning algorithm based on these different parameters, we can obtain a more complete classification system for galaxies in the Siena Galaxy Atlas (SGA), a catalog of 383,620 nearby galaxies.

**Searching for Strong Gravitational Lenses in DESI Spectra**

Delaney Cummins, Segev BenZvi and Xinyi Chen, University of Rochester

Strong gravitational lensing systems are typically observed in imaging surveys via rings, multiple images, or other visual effects on the source galaxy. However, we expect to see 5 to 10 times more strong lensing systems with Einstein radii smaller than the resolution of most imaging surveys. These systems may be found using spectroscopy, and their detection would dramatically increase the number of known lensing systems, improving our chances to perform time-delay cosmography and other cosmologically significant studies. We train a vision transformer neural network (ViT) to find strong lensing systems in DESI spectra. The ViT classified lenses and non-lenses with >85% accuracy after training.

## SESSION II. POSTER SESSION

### Development of Using Solar Renewable Energy in our Daily Lives

Adam Choudhry and Malek Abunaemeh, St. John's University

Solar renewable energy is something that everyone always asks and want for at their homes because there are lots of benefits to having solar energy at their homes. Solar renewable energy is good for bringing electricity in people's houses with a source that comes from the sun. We need air conditioners to stay cool in those hot times. It also helps reduce families spending a lot of bills to pay for electric power and is good for the environment because it does not burn fossil fuels, decreasing carbon dioxide emissions. Solar energy is also reusable for everyone because once consumers purchase it, they don't have to repurchase it.

As for us, physics major students of the Physics Department in St. John's University, we can design smaller solar energy panels that can be very much equivalent to the bigger solar energy in order for us (people) to place solar panels in different angles of the roofs of their homes where the sun hits. They are big in size and very costly to purchase, so making them in different sizes can help it be more accessible to people, especially cost wise. It will also be beneficial to have solar energy at times when the weather is super frigid, and they need to turn on the heaters in order to stay warm inside their homes and for all seasons. This way, paying electric bills can be reduced and making everyone's life easier and simpler with having solar renewable energy in our daily lives.

### Machine learning enhanced Quantum light detection

Nalin Cooper-Sherron and Timothy Thomay, SUNY Buffalo

Quantum light is a specific type of light that cannot be described using classical physics. It has many applications in Quantum technologies such as Quantum sensing and communication. Currently, one of the biggest challenges to generate Quantum light sources is to develop efficient data analysis schemes that allow the Quantum Properties of the emitter to be determined. modern data algorithms based on machine learning and specialized hardware recently allowed the Quantum state of light to be determined in quasi-realtime. This project aims to combine Quantum light detection with machine learning data analysis.

**Analyzing Cryogenic Implosion Data**

Rafael de Farias, Dean Clasby and Jim Knauer, University of Rochester

This project analyzed the necessary adjustments due to instrument error for the detectors measuring neutron and x-ray data from cryogenic implosion shots performed with the OMEGA Laser System. Data from the scattered x-ray and neutron from the fusion reaction is collected in one of ten detectors. Each detector is equipped with four channels, three channels which record the measured voltage produced by the photomultiplier tube with respect to time, and a fiducial channel for calibrating the timing of the data. This project used thirteen calibration shots that were adjusted using fiducial data. The x-ray data for these shots was then fitted to an Instrument Response Function (IRF) to take into account instrumental error. With this data analysis tool available, neutron and x-ray peak data for non-calibration shots can be analyzed with more precision.

**A Temperature Control Stage for the Deposition of Thin Metal Films**

Owen Fall, Luke Yelle and Brandon Hoffman, Houghton University

A thermal substrate stage was developed for physical vapor deposition of thin metal films. The stage can maintain a uniform, constant temperature across a 4 cm diameter substrate throughout the deposition process, even while it is being radiatively heated at ~5 W for 10 min by the evaporate metal. The substrate is adhered to an 11 cm diameter, 6.4 cm long aluminum heat sink. Previous experiments concluded that Ag paste produced the best thermal contact between the substrate and heat sink. To balance the most surface area possible for thermal contact and removability of the paste, grooves were made in the heat sink. The control stage features ceramic standoffs, holding the aluminum heat sink to the inside of the deposition chamber, and a heater wire pasted to the heat sink to initialize and stabilize the desired temperature.

**Social Outreach through Adelphi University's Physics Department**

Kylie L. Goldade, Victoria S. Wynter, Jason P. Bier, Matthew J. Wright, Adelphi University

We will report our findings about doing physics outreach through Adelphi University. We do various events through Lab4Kids which is a program that allows us to travel to high schools to teach students, as well as them being able to visit Adelphi. In this program, we taught children (grades K - 12) in groups of up to 32 students following the NYS Curriculum and beyond, traveled to high schools, and brought students back to our nationally recognized STEM University. Because of the opportunities from this program, three of our student teachers were invited to teach for the 21st Century Community Learning Centers RamPathways Program at the West Hempstead School District. This program allowed us to teach STEM Enrichment during the summer following a common core aligned curriculum, designing, writing, and implementing lessons for subjects including optics, electrostatics, electromagnetism, and forces, as well as modifying assignments for students with disabilities and special needs. Victoria Wynter taught 12, 5th-grade students at George Washington Elementary School. Kylie Goldade taught 23, 6th-grade students at George Washington Elementary. Jason Bier taught 15, 7th, and 8th grade students at West Hempstead Secondary School.

**Identifying Massive Quiescent Galaxies with COSMOS-Web: The JWST Cosmic Origins Survey**

Mimi Harrison and Jeyhan Kartaltepe, Rochester Institute of Technology

Massive galaxies exhibit a bimodal distribution in the Universe, consisting of active star-forming and quiescent populations persisting through high redshifts. In a cosmologically young Universe only a few billion years old, it is a mystery how massive galaxies could have become quenched of star formation in such significant numbers so quickly. This phenomenon is not predicted nor explained by theoretical models of galaxy evolution and hierarchical structure formation models- suggesting that galaxy evolution in the early Universe may differ dramatically from what we observe in the current Universe. With access to revolutionary observational equipment, exploring these rare galaxies from the early Universe is possible with larger sample sizes than previously possible. We present a sample of quiescent galaxy candidates selected from the COSMOS-Web catalogs by using rest-frame color-color diagrams with F115W, F150W, F277W, F444W, and F770W filters to identify these galaxies and distinguish them from active star-forming ones. Spectral Energy Distribution (SED) models from photometric COSMOS-Web data can test whether these candidates fit typical quiescent galaxies' SED profiles. Future steps to utilize spectroscopic quiescent candidate galaxy data from the Keck Observatory will allow for further study and test the efficacy of color-color techniques at higher redshifts.

**Validating Mass-Loss Measurements in Newly Forming Young Stars**

Prince Aziz Hunt and Dr. Michael Dunham, SUNY Fredonia

As stars are forming, mass is ejected in conically shaped outflows from their poles of rotation. The amount of mass ejected depends on the width of the conical outflow, which affects the final mass of the star. The research being performed in this project focuses on the validation of existing measurements of the width of outflows, through the use of a new set of telescope images. The intention of using this different set of images is to test the accuracy of current techniques, and determine whether or not there needs to be an adjustment in how they're measured.

**Persistence of Correlations in Neurotransmitter Transport Through the Synaptic Cleft**

Masroor Khonkhodzhaev, Shota Maglakelidze, Yonatan Dubi and Lev Mourokh, CUNY Queens College

The "quantum brain" proposal can revolutionize our understanding of cognition if proven valid. In this work, we examine the preservation of the correlations created in the pre-synaptic neurons through the transfer of neurotransmitters across the synaptic cleft. We simulate transport of two neurotransmitters at two different clefts, with the only assumption that they start simultaneously, and determine the difference of their first passage times. We show that in physiological conditions, the correlations are persistent even if the parameters of the two neurons are different.

**Investigating Radiative Levitation in White Dwarf Stars by Large-Scale Molecular Dynamics Simulations**

Annie Maloney, Brennan Arnold, Eric Blackman, S. X. Hu, University of Rochester

It has been observed that the abundance of heavy elements in the atmospheres of white dwarf stars does not match exactly with prevailing stellar models. The phenomenon of radiative levitation is one possible explanation, wherein due to the high opacity of heavy elements such as C, Si, and Fe, these elements are "levitated" against the force of gravity within a plasma of Hydrogen and/or Helium. This mechanism is not entirely understood at the microscopic level, particularly in regards to plasma density and temperature conditions. To investigate this phenomenon we use large-scale molecular dynamics simulations to model what happens in white dwarf stars. Considering at first only the case of 1% Si in Hydrogen, a simulation is performed with LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator) that describes the physics of such a system. Methods are developed to calculate the radiative force, as well as output and analyze velocity data afterwards, for which we will expect to see some drift of the velocity distribution in cases where the radiative force is applied. By scanning different density and temperature conditions of the white dwarf atmosphere, this study will reveal where radiation levitation may play a role to redistribute heavy elements in white dwarf stars.

**Using Social Network Analysis to Understand Community Within an Introductory Physics Course**

Jessica Nagasako and Dr. Geraldine L. Cochran, University of Rochester

Social Network Analysis (SNA) provides a powerful way to assess social structures within communities. Brewe et al., (2015) found that centrality, a measure of a person's importance or role within a community, can predict student success as determined by their physics course grades. Bruun and Brewe (2013) found that social interactions correlated positively with physics conceptual inventory performance and physics course grade. We aimed to create a visual network of an introductory physics course's social structure. Using Python, we turned survey responses on students' interactions and group affiliations into a visual network of the class. Following Institutional Review Board (IRB) protocol, we replaced student names with randomly assigned numbers. From there we created an edge list that was used to create the visual network of the classroom. This network allowed us to identify students central to the network (most connected) and students isolated from the network (not connected to any other students). Our visual analysis of the network allowed us to identify students central to the network (most connected) and students isolated from the network (not connected). Our data supports that students in affinity-based professional groups are most central in the classroom network. Additionally, we found that there were no isolated students in the network.

**Decomposing MaNGA Galactic Rotation Curves to Model Dark Matter Halos**

Lara Stroud, Yifan Zhang, Nitya Ravi and Kelly Douglass, University of Rochester

The rotational velocity of a spiral galaxy should be consistent with the expected curve from the mass distribution of the galaxy, however observed rotation curves are much higher than their visual mass distributions would suggest. This forms the basis for the theory of dark matter. Determining the rotation curve of a spiral galaxy thus allows for the measurement of visible and nonvisible matter in the galaxy. The goal of this project is to decompose rotation curves from SDSS MaNGA velocity maps into visible and nonvisible components to compare dark matter halo models.

**Measurement of Water Diffusion Coefficient in Cross-Linked Gelatins Using the Terahertz Time-Domain Spectroscopy Technique**

Declan Walden, Debamitra Chakraborty, Jing Cheng, Antanas Straksys, Arunas Stirke, Wanessa CMA Melo, Arturas Jukna, Ivan V. Komissarov, and Roman Sobolewski, University of Rochester

Gelatin exhibits excellent biodegradability, biocompatibility, adhesion, and absorption properties. This polymer can undergo varying degrees of cross-linking with glutaraldehyde (GTA) and linked with water to form a hydrogel. The water diffusion coefficient serves as an important parameter governing the applicability of hydrogels. Various techniques can be employed to measure water diffusion in gelatin hydrogels, including quasi-elastic neutron scattering, nuclear magnetic resonance, side-by-side diffusion cells, fluorescence correlation spectroscopy, the refractive index method, among others. In this study, we introduce a novel method for determining water diffusion in gelatin hydrogels based on transient terahertz time-domain spectroscopy (THz-TDS). The diffusion coefficient is derived from the temporal evolution of experimentally measured water-concentration profiles using THZ-TDS. Assuming Fickian diffusion, the water diffusion coefficient is estimated to be 2.53 * 10^–6 cm2/s, falling within the range of reported values for water diffusion coefficients in gelatin literature.

**Sequence heuristics to program nucleic acid phase separation**

Corey J. Young, Gable M. Wadsworth and Priya R. Banerjee, SUNY Buffalo

The phase separation of RNA and proteins is ubiquitous in biological systems, an important example being the formation of membrane-less ribonucleoprotein organelles such as the stress granules and the nucleolus in living cells. The majority of the past and current studies are focused on understanding the molecular rules of phase separation of proteins. RNAs can also undergo phase transitions in the absence of proteins. However, the physicochemical driving forces of protein-free, RNA-driven phase transitions remain unclear. We recently demonstrated RNAs undergo lower critical solution temperature (LCST)-type phase separation upon heating (Nature Chemistry, 2023; DOI: 10.1038/s41557-023-01353-4), which is driven by the desolvation of the phosphate backbone in the presence of Mg+2 ions and tuned by nucleobases. Here we uncover the potential for systematic perturbation of the RNA phase separation. Selecting a simple yet diverse set of parameters, such as divalent ions, molecular crowding, and sequence variation to tune RNA phase behavior, our work establishes novel heuristics to encode programmable temperature-controlled RNA condensation into reversible and percolated fluids.

## SESSION IIIA. NUCLEAR & PARTICLE PHYSICS

### Target Normal Sheath Acceleration as a Technique for Measuring Nuclear Cross-Sections

Andrew Martin and Mark Yuly, Houghton University

A Multi-Terawatt Laser (MTW) experiment was performed at the Laboratory for Laser Energetics (LLE) to test the feasibility of using Target Normal Sheath Acceleration (TNSA) to measure 0.1-10 MeV light-ion cross sections, especially those involving tritium. In this initial experiment using deuterium, laser pulses (∼22 J, 7 ps) struck a 0.25 mm2 deuterated polyethylene (CD2) target, ejecting TNSA deuterons that hit a ~2 µm thick natural Li target film on a 25 µm thick stainless-steel substrate, causing the 7Li(d,p)8Li reaction. The Short-Lived Isotope Counting System (SLICS), consisting of the phoswich scintillator, light guide, and photomultiplier, was placed immediately behind the Li target, and a high-speed CAEN Digitizer was used to count the 840 ms half-life beta decay of 8Li, starting a few milliseconds after the laser shot. The phoswich detector consisted of a fast thin and slow thick scintillator sandwiched together to allow incident particles to be identified by their different rates of energy loss. Incident deuteron energy spectra were measured using time-of-flight (TOF) to a small scintillator in front of the Li target and, for comparison, with a Thompson parabola spectrometer.

### Error-resilient quantum simulations with pulse-based techniques in the Schwinger model

Tom McEntire, University at Buffalo

Quantum computers have the potential to solve Hamiltonians that are currently intractable on powerful classical computers. Simulating a Hamiltonian approximation of lattice gauge theories on a quantum computer requires circuits containing many gates, accumulating aggregate errors, and limiting the size of any lattice problem. A possible solution is to use tailored pulse-level control of a quantum computer, combining multiple gates into single physical operations, and minimizing the sources of errors. We created an algorithm to simulate lattice gauge theories with minimal pulses rather than discrete gates. We utilized the variational quantum eigensolver (VQE) in PennyLane with pulses to prepare the ground state of the Schwinger model, a (1+1) dimensional U(1) gauge theory. The Schwinger model exhibits color confinement and chiral symmetry breaking, similar to Quantum Chromodynamics (QCD). We will compare the runtime of the pulse VQE to circuits with pulse gates, assessing error accumulation.

**Refining Straw Detector Capabilities for DUNE Experiment**

Shaib Sharhan, Manhattan College

This research project, conducted at the European Organization for Nuclear Research (CERN) during the summer, aimed to advance the field of neutrino detection through innovative methodologies and state-of-the-art technology. Neutrinos, with negligible mass and no electric charge, play a fundamental role in the universe, yet their detection remains a significant challenge. The Deep Underground Neutrino Experiment (DUNE) aims to discover new physics with these elusive subatomic particles. I collaborated with scientists from the RD-51 team to optimize a DUNE, SHIPE, RD61, and RD61-upgrade straw tube detection mechanism. While there, I managed to maximize pressure, eliminate all voltage leaks, reconstruct the setup for better efficiency, and collect live muon neutrino beam data. Our team demonstrated significant advancements in neutrino detection capabilities, with increased sensitivity to low-energy neutrino events and improved angular resolution.

**SESSION IIIB. ASTRONOMY & ASTROPHYSICS**

**X-ray Observation of the Gamma-Ray Emitting Radio Galaxy: NGC 315**

Allison Blum, Ka-Wah Wong, Rodrigo S. Nemmen, Jimmy Irwin and Dacheng Lin, 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. Multiwavelength 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. We further study the origin of the X-ray emission using the Chandra X-ray Observatory, utilizing the high-resolution images created by the deconvolution method.

**Scalar Field Limits for a Dark Big Bang**

Richard Casey and Dr. Cosmin Ilie, Colgate University

Years of unsuccessful detection of Weakly Interacting Massive Particles (WIMPs) has led to the development of new models for dark matter. One of these models considers dark matter particles that have no interactions with particles of the Standard Model other than through gravity. In this case, the origins of visible and dark matter can occur at different times, leading to the theory of a Dark Big Bang. The dark sector is initially populated by a real scalar field which decays into dark matter particles and gravity waves through the Dark Big Bang. This research focuses on constraining the parameters of this scalar field to have a Dark Big Bang consistent with observational data.

**Pion Lagrangian for large-scale-structure in cosmology**

Bhavya Mishra and Dr. Bart Horn, Manhattan College

We simulate an efficient numerical model for Large-Scale Structure in Universe in terms of coupled partial differential equations inspired by soft-pion theorems from high energy physics. We present this by describing LSS in terms of a simple pion fluid, using Fast Fourier transformation and other methods to improve computation time and techniques. We analyze the evolution of the pion field and its power spectrum over time. We also discuss work in progress related to more efficient simulating techniques for LSS over parallel processing algorithms.

## SESSION IVA. INSTRUMENTAL / EXPERIMENTAL TECHNIQUES

### Studying the Properties of Niobium Oxide

Sean Lannon, Zachary Robinson, Matt Sullivan, Karsten Beckmann and Nate Cady, SUNY Brockport

Niobium oxide is a strong candidate for implementation into neuromorphic computer technology. The purpose of this research is to develop synthesis and crystallization processes for making thin films of niobium oxide so that the material can be better understood and eventually incorporated into next-generation computers. More specifically, we studied the environmental conditions required for the material to undergo crystallization. We built a vacuum system with a regulated inflow of gas and a furnace so that we could control the temperature and pressure of the sample's environment. The samples were measured using microscopic image analysis and Raman spectroscopy. We found that the samples underwent the most crystallization at pressures around atmospheric pressure, and temperatures around 900 ℃. Crystallization only occurred when using an ambient of nitrogen/hydrogen gas mixture at 95%/5%. Crystallization did not consistently occur in any samples below 900℃ or below a pressure of 100 Torr. The only samples to fully crystalize were at standard atmospheric pressure (760 torr) and 1000℃. Partial crystallization was observed at 1000℃ under pressures between 100 torr and 500 torr and at 900℃ under atmospheric pressure. We have concluded that these are temperature and pressure thresholds that dictate the crystallization process of niobium oxide.

### Deposition System for Thin Lithium Nuclear Targets

Chunsun Lei and Mark Yuly, Houghton University

A system was developed to create Sn or Ag coated Li nuclear targets for ICF simulation and Target Normal Sheath Acceleration (TNSA) experiments. The purpose of these experiments is to develop ways to measure low energy light-ion cross section using high-power, ultra-fast lasers. The Li targets were designed to have a ~50 nm thick coating to over a 2 mm thick Li film to prevent the Li from reacting with air and water vapor. The films were produced in a ~10−5 Torr evacuated deposition chamber. Approximate 15 A flowing one way through a diode circuit heated a stainless-steel boat holding a Li pellet to a thermocouple-measured temperature of nearly 400 °C, evaporating the Li onto a 25 µm thick stainless-steel substrate. A current of up to 60 A flowing the opposite direction through another diode heated a molybdenum boat holding a Sn or Ag pellet, evaporating the metal and forming the thin coating over the Li. The film thicknesses were measured using Rutherford backscattering, a magnetic adhesion tester, and a home-made profilometer. To allow Li metal to be weighed and inserted onto the boat without oxidization, an Air-filled glove box was constructed around the deposition chamber.

**Crystallization and Resistivity of Niobium Oxide Samples**

Emma Sargent and Zachary Robinson, SUNY Brockport

Since transistors are nearing their physical limit in terms of size, significant research has focused on computational architectures inspired by biological processes. A major circuit competent of so-called “neuromorphic” computing is the memristor, a device that is influenced by its previous state history. Niobium dioxide, NbO2, is an attractive memristive material due to its controllable, reversible electronic properties. My research focuses on finding the ideal conditions needed for niobium dioxide to crystallize and building and testing an instrument for measuring the electrical properties of the crystallized material. To do this, we conducted a series of tube-furnace anneals, ranging from 800-1000 degrees Celsius, on amorphous niobium oxide films deposited on silicon wafers. We analyzed our annealed samples through optical microscopy and Raman spectroscopy to confirm that the crystals seen in the images are actually NbO2. To study the resistivity, we plan to use the Van der Pauw technique. For my research, I designed and 3D printed a series of Van der Pauw setups and did preliminary measurements on a thin film of gold. Since this work is ongoing, I plan to present my latest data on the resistivity of the gold calibration samples and our annealed niobium dioxide films.

## SESSION IVB. INSTRUMENTATION/EXPERIMENTAL TECHNIQUES / NUCLEAR AND PARTICLE PHYSICS / CONDENSED MATTER PHYSICS

### Phase Measuring Laser Feedback Interferometry with PID Control

Avery Gilson and Dr. Ben Ovryn, New York Institute of Technology

Using a broadband electro-optic phase modulator with a laser feedback interferometer enables measurements with phase shifting and lock-in approaches. We have calibrated the response of a piezoelectric translator and measured the dynamic response of a 5-axis robotic arm. A field programmable gate array (FPGA) offers the benefit of rapid phase measurements as well as closed loop control. Phase shifting laser feedback interferometry readily produces kHz phase measurements with better than 5 nm precision. Phase unwrapping can be used to follow micron changes in the optical path length. Our calibration of a commercial piezoelectric translator is in close agreement with vendor specifications. Stepper motors on the robotic arm combined with kinematic calculations produce accurate, large scale sample displacements (centimeter scale) while the laser feedback interferometer adds nanometer precision.

### Parameterizations of electron scattering form factors for elastic scattering and electron-excitation of nuclear states for 27 Al

Amii Matamoros, Arie Bodek, M.E. Christy and Zihao Lin, University of Rochester

We report on parameterizations of nuclear excitation longitudinal and transverse nuclear electromagnetic form factors measured in electron scattering on 27 Al nuclei. For the elastic and nuclear excitations with excitation energies below 8 MeV we use all published form factors. These parameterizations can be used to calculate radiative corrections for electron scattering cross sections on 27 Al nuclear targets.

**Targeted Enhancement of Second Harmonic Generation in Layered Transition Metal Dichalcogenides using Structured Light**

Russell Berger, Alex Mavian, Nazifa Rumman, Pascal Bassène, Humberto Terrones and Moussa N'Gom, Rensselaer Polytechnic Institute

Two-dimensional transition metal dichalcogenides (TMDs) are exciting candidates for miniaturizing nonlinear optical systems due to their high second-order nonlinear susceptibility. However, strong second harmonic generation (SHG) responses are currently hindered by their nanometer-scale interaction length, compounded by other physical factors, such as grain boundaries and multilayer growth, which limit the spatial degrees of freedom for signal generation. We incorporate wavefront shaping (WFS) techniques to enhance the weak SHG response of few-layered WS2 samples. Star-shaped polycrystals are examined for their weak SHG signal at both grain boundaries and the center of the crystal. We observe a significant targeted enhancement of the second-order nonlinear response in selected regions by up to an order of magnitude and report an increased conversion efficiency in these regions. Our work demonstrates how structured light can amplify weak nonlinear interactions, allowing for all-optical tuning of the nonlinear optical response in TMDs and paving the way for applications in nonlinear microscopy, nanophotonics, and materials characterization.

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