RSPS

40 Year Anniversary

Rochester Symposium for Physics, Astronomy & Optics Students

SPS Zone 2 Regional Meeting

April 9, 2022

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

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

University of Rochester, April 9, 2022

Dear Participants:

Welcome to the 40th annual Rochester Symposium for Physics Students (RSPS). The RSPS was instituted to provide an opportunity for undergraduates to present an account of their own personal research at a meeting whose format was chosen to closely resemble those of professional scientific societies.

At these symposia, research projects are presented in talks or poster sessions by undergraduates representing many regional institutions. Topics include condensed-matter physics, atomic physics and optics, computational physics, astronomy, particle and nuclear physics, instrumentation and techniques, environmental physics, biological physics, medical physics, and educational physics. The abstracts of all the participants' papers are published annually in the RSPS proceedings and distributed to the participants. The information is also available on line at: http://www.pas.rochester.edu/news-events/rsps/2022/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
THOMAS AHRENS	9:00 AM	B&L 109
AIDAN BACHMANN	10:00 AM	LOBBY
MATTEW BOWMAN	10:00 AM	LOBBY
JOSHUA BOWMAN	11:15 AM	B&L 106
ADAM BROWN	10:00 AM	LOBBY
NATHANIEL BRUNACINI	9:15 AM	B&L 109
JACOB COONEY	2:15 PM	B&L 106
NATHANIEL DAVIE	11:45 AM	B&L 106
NICHOLAS DIBRITA	9:00 AM	B&L 106
PARKER FAIRFIELD	9:30 AM	B&L 106
WILL FRIEND	10:00 AM	LOBBY
RALUCA GHILEA	10:00 AM	LOBBY
JOSEPH GLICHOWSKI	2:00 PM	B&L 106
ANDREW HOTCHKISS	10:00 AM	LOBBY
CHRISTOS KAKOGIANNIS	10:00 AM	LOBBY
NOAH KLEIN	11:30 AM	B&L 106
MARVIN LOPEZ	10:00 AM	LOBBY
MICHELE MANNO	11:00 AM	B&L 109
ERIC MATT	10:00 AM	LOBBY
TED MBURU	10:00 AM	LOBBY
ALEXANDER MESITI	2:30 PM	B&L 106
RYAN O'CONNOR	10:00 AM	LOBBY
TIMOTHY OCKRIN	10:00 AM	LOBBY
HUGH RANDALL	11:15 AM	B&L 109
JOSHUA RATAJCZAK	9:30 AM	B&L 109
EMMA SARGENT	9:45 AM	B&L 106
EDMUND SEPEKU	9:45 AM	B&L 109
COLIN STEINER	2:00 PM	B&L 109
PAUL SUFLITA	2:45 PM	B&L 106
NAVYA UBEROI	2:30 PM	B&L 109
JOSEPH VARGAS	11:00 AM	B&L 106
JOSHUA WILSON	10:00 AM	LOBBY
JAMIE WOODWORTH	10:00 AM	LOBBY
XINYUE WU	2:15 PM	B&L 109
ZACH YEK	11:30 AM	B&L 109
CHANJU (ZOE) YOU	9:15 AM	B&L 106
YIFAN ZHANG	11:45 AM	B&L 109

XL 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: PROF. FRANK WOLFS, UNIVERSITY OF ROCHESTER (B&L 109)

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

SESSION CHAIR: PROF. CANDICE FAZAR, ROBERTS WESLEYAN COLLEGE

9:00 AM **Searching for Core-Collapse Supernovae with High-Energy Neutrinos at IceCube**
Thomas Ahrens
University of Rochester
Advisor: Prof. Segev BenZvi

9:15 AM **Determining the metallicity gradient across galaxies in SDSS MaNGA**
Nathaniel Brunacini
University of Rochester
Advisor: Prof. Kelly Douglass

9:30 AM **Testing the Robustness of ConKer on the Intergalactic Medium: A New Method of Measuring the 2-Point Correlation Function of the Universe's Neutral Hydrogen Gas**
Joshua Ratajczak, Zachery Brown, Regina Demina, Gebri Mishtaku
University of Rochester
Advisors: Prof. Kelly Douglass, Prof. Regina Demina, Dr. Satya Gontcho A Gontcho

9:45 AM **Spectroscopic Search for Transients using the Dark Energy Spectroscopic Instrument**
Edmund Sepeku
University of Rochester
Advisor: Prof. Segev BenZvi

9:00 AM – 10:00 AM: SESSION IB. QUANTUM OPTICS & CONDENSED MATTER PHYSICS (B&L 106)

SESSION CHAIR: PROF. ZACHARY ROBINSON, SUNY BROCKPORT

9:00 AM	**Hong-Ou-Mandel Interference with a Fibered Beam Splitter** Nicholas S. DiBrita **Colgate University** Advisor: Prof. Enrique J. Galvez
9:15 AM	**Quantum Mueller Polarimetry** ChanJu (Zoe) You **Colgate University** Advisor: Prof. Enrique J. Galvez
9:30 AM	**Demonstration of phase transitions using a 1D longitudinal mechanical topological insulator** Parker Fairfield, Luke Thatcher, Juan Merlo-Ramírez **Vassar College** Advisor: Prof. Juan Merlo-Ramírez
9:45 AM	**Annealing and Characterization of Zinc Doped Niobium Oxide for Neuromorphic Computing Applications** Emma Sargent, Alex Mesiti, Nicole Zhe, Andrew Rowley, James Michels, Zachary Robinson, Karsten Beckmann, Nate Cady, Timothy Walters, Hans Cho, Alex Kozen **SUNY Brockport** Advisor: Prof. Zachary Robinson

10:00 AM – 11:00 AM: SESSION II. POSTER & CHAPTER EXHIBITION SESSION (B&L LOBBY & 203H)

An Experiment to Simulate Trapping and Detection of Radioactive Isotopes Produced in ICF Implosions
Adam E. Brown, Micah J. Christensen, Micah K. Condie, Mark Yuly, James G. McLean, Stephen J. Padalino, Chad J. Forrest, Thomas C. Sangster, Sean P. Regan
Houghton College
Advisor: Prof. Mark Yuly

Producing the 2H (d,n) 3He reaction with the Houghton College Cyclotron
Andrew Hotchkiss, Joshua Bowman, and Mark Yuly
Houghton College
Advisor: Prof. Mark Yuly

Statistical Effects of Synthetic Template Mismatch with Model DEIMOS Observations
Christos Kakogiannis
Union College
Advisor: Prof. Jonathan Marr

Enabling Unsupervised Learning in a Josephson Junction Neural Circuit
Eric Matt
Colgate University
Advisor: Prof. Ken Segall

Using a Numerical Model to Investigate the Analytical Limits of Thermal Diffusion
Jamie Woodworth
Ithaca College
Advisor: Prof. Matthew C. Sullivan

An Ambient Air Scanning Tunneling Microscope to Study the Surfaces of Thin Metal Films
Joshua Wilson and Brandon Hoffman
Houghton College
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Deep Sky Astrophotography & Detecting the Properties of an Eclipsing Binary-Star System Using Differential Transit Photometry
Marvin Lopez, Richard McCoy
Hamilton College
Advisor: Prof. Adam Lark

A New Evaporator for the Houghton College Deposition Chamber
Matthew Bowman and Brandon Hoffman
Houghton College
Advisor: Prof. Brandon Hoffman

Phase Unwrapping for Interferometry using a Radial Basis Function Neural Network
Aidan Bachmann and Pierre Gourdain
University of Rochester
Advisor: Prof. Pierre Gourdain

Unsupervised Learning in Josephson Junction-Based Spiking Neural Networks
Raluca Ghilea
Colgate University
Advisor: Prof. Ken Segall

Synthesizing Iron Oxide Nanoparticles for Water Purification
Ryan O'Connor, Sam Lotemple, Dr. Kristen Repa
SUNY Brockport
Advisor: Prof. Kristen Repa

Creating an Interactive Simulation for Rotating Reference Frames
Ted Mburu, Antara Sen
Ithaca College
Advisor: Prof. Colleen Countryman

Simulating Low Temperature Detector Pulse Streams and Developing Edge Triggers
Timothy R. Ockrin and Katrina E. Koehler
Houghton College
Advisor: Prof. Katrina Koehler

Unsupervised Learning In Josephson Junction Circuit
Will Friend
Colgate University
Advisor: Prof. Ken Segall

11:00 AM – 12:00 PM: SESSION IIIA. ASTRONOMY AND ASTROPHYSICS (B&L 109)

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

11:00 AM **Interior Luminosity Curves of Cepheid Variables**
Michele Manno, L. Samson, S.Kalici, H. Randall, D. Podos, N. Proietti, AJ Chalmers, S. Das, E. Bellinger, A. Bhardwaj, S. Kanbur
SUNY Oswego
Advisor: Prof. Shashi Kanbur

11:15 AM **Linearized Stellar Pulsation Calculations for 3 Types of Variable Star**
Hugh Randall, A. Chalmers, N. Proietti, S. Kalici, M. Manno, D. Podos, S. Kanbur, E. Bellinger, S. Das, A. Bhardwaj
SUNY Oswego
Advisor: Prof. Shashi Kanbur

11:30 AM **Applying ML Methods to blc1: Breakthrough Listen's First Signal-of-Interest**
Zach Yek, Sofia Sheikh, Bryan Brzycki, Peter Ma, Dominic LeDuc, Matt Lebofsky, Vishal Gajjar, Steve Croft
SUNY Fredonia
Advisor: Prof. Sofia Sheikh

11:45 AM **Decomposition of Galactic Rotation Curves**
Yifan Zhang
University of Rochester
Advisor: Prof. Kelly Douglass

11:00 AM – 12:00 PM: SESSION IIIB. NUCLEAR AND PARTICLE PHYSICS / INSTRUMENTATION & EXPERIMENTAL TECHNIQUES (B&L 106)

SESSION CHAIR: PROF. MARK YULY, HOUGHTON COLLEGE

11:00 AM	**Observing Monoenergetic KDAR Neutrinos in the ICARUS Detector** Joseph Vargas **SUNY Fredonia** Advisor: Prof. Chris Marshall
11:15 AM	**Deuterium-Deuterium Fusion in the Houghton College Cyclotron** Joshua Bowman, Andrew Hotchkiss and Mark Yuly **Houghton College** Advisor: Prof. Mark Yuly
11:30 AM	**The Houghton College Interferometer** Noah Klein and Brandon Hoffman **Houghton College** Advisor: Prof. Brandon Hoffman
11:45 AM	**Construction and Calibration of the Houghton X-ray Diffractometer** Nathaniel Davie and Brandon Hoffman **Houghton College** Advisor: Prof. Brandon Hoffman

12:00 PM – 2:00 PM: LUNCH, PHYSICS CAREER TALK BY DR. RACHEL IVIE & PHYSICS JEOPARDY (RUSH RHEES LIBRARY – HAWKINS-CARLSON ROOM)

2:00 PM – 2:45 PM: SESSION IVA. ASTRONOMY AND ASTROPHYSICS (B&L 109)

SESSION CHAIR: PROF. LINDA TSENG, COLGATE UNIVERSITY

2:00 PM	**NuSTAR Observation of the TeV-Detected Radio Galaxy: 3C 264** Colin Steiner, Ka-Wah Wong, Dacheng Lin, Jimmy Irwin, Rodrigo Nemmen **SUNY Brockport** Advisor: Prof. Ka-Wah Wong
2:15 PM	**Predicting the IceCube Response to Neutrino Bursts from Core Collapse Supernovae** Xinyue Wu **University of Rochester** Advisor: Prof. Segev BenZvi
2:30 PM	**Measuring Peculiar Velocities with the Dark Energy Spectroscopic Instrument using the Tully-Fisher Relation** Navya Uberoi **University of Rochester** Advisors: Prof. Segev BenZvi, Prof. Kelly Douglass

2:00 PM – 3:00 PM: SESSION IVB. BIOLOGICAL PHYSICS / OTHER (B&L 106)

SESSION CHAIR: PROF. KATRINA KOEHLER, HOUGHTON COLLEGE

2:00 PM	**Mechanosensitivity of Epithelial Layer Maturation** Joseph Glichowski **University of Rochester** Advisor: Prof. Dan Bergstralh
2:15 PM	**Mobile Observations of Major Methane Sources in New York State** Jacob Cooney **Ithaca College** Advisor: Prof. Eric Leibensperger
2:30 PM	**Annealing of Titanium Doped Niobium Dioxide** Alex C. Mesiti, Emma G. Sargent, Zachary R. Robinson, Carl A. Ventrice Jr., Karsten Beckmann, Nate Cady, Matthew Sullivan, Tim Walters, Hans Cho, Alex Kozen **SUNY Brockport** Advisor: Prof. Zachary Robinson
2:45 PM	**Characterization of niobium-oxide devices** Paul Suflita **SUNY Brockport** Advisor: Prof. Zachary Robinson

SESSION IA. ASTRONOMY AND ASTROPHYSICS

Searching for Core-Collapse Supernovae with High-Energy Neutrinos at IceCube

Thomas Ahrens, University of Rochester

Core-collapse supernovae (CCSNe) are known to be sources of MeV neutrinos, but they may also produce high-energy neutrinos (>1 TeV) via acceleration of cosmic rays after the initial explosion. The IceCube Neutrino Observatory, a gigaton ice Cherenkov detector at the South Pole, detects neutrinos between $\sim$1 GeV to greater than 1 PeV. We construct a catalog of core-collapse supernovae and compare IceCube data with the emission of transients in the catalogue to test if these objects are the origin of high-energy neutrinos. With several technical improvements requiring minimal computational cost, we can expand the catalogue of sources without making assumptions about their relative neutrino luminosities. A positive correlation between core-collapse supernovae and neutrinos observed with IceCube would confirm these objects as cosmic-ray accelerators.

Determining the metallicity gradient across galaxies in SDSS MaNGA

Nathaniel Brunacini, University of Rochester

We study the gas-phase chemical abundance (metallicity) gradient of galaxies in the nearby universe to better understand how large-scale structure impacts star formation. Galaxies in the least dense regions of the universe (void galaxies) are expected to have a shallower gradient than galaxies in denser regions (wall galaxies), since void galaxies undergo significantly fewer interactions and therefore are expected to have experienced less star formation. Because star formation converts lighter elements into heavier ones, the metallicity gradient should provide insight into the star formation history of galaxies by measuring the level of heavier elements present as a function of location. We use the 3D metallicity calculation method described by Pilyugin and Grebel (2016) to determine the metallicity at each spatial pixel (spaxel) within each of the roughly ten thousand nearby galaxies observed in the SDSS MaNGA survey. For each galaxy, we fit a line to the metallicity values with respect to the normalized radius of each spaxel from the galactic center. The slope of this line corresponds to the chemical abundance gradient of the galaxy. We compare the gradients for void galaxies with those of galaxies in denser regions to study how the void environment affects their star formation history.

Testing the Robustness of ConKer on the Intergalactic Medium: A New Method of Measuring the 2-Point Correlation Function of the Universe's Neutral Hydrogen Gas

Joshua Ratajczak, Zachery Brown, Regina Demina, Gebri Mishtaku, University of Rochester

We study the distribution of matter in our universe in order to better understand its evolution and history. The matter in our universe is not randomly distributed but instead clusters along an underlying pattern of dark matter. Baryonic Acoustic Oscillations (BAO) are distinguishable features of overdensity in the matter distribution with a distinct spherical-shell shape that has a measurable radius for a given moment in the history of the universe. Due to the universe being in expansion, the size of the BAO pattern depends on the stage of the universe at which the measurement is made. Measuring this radius allows us to constrain the cosmological parameters that characterize our universe. We measure the BAO radius by looking at how the position of matter overdensities are correlated to other matter overdensities through the 2-point correlation function (2pcf). Originally developed for use on galaxies, ConKer has the potential to be an extremely efficient algorithm for calculating the correlation function and measuring the BAO radius using the intergalactic hydrogen gas. Given that our universe is permeated with neutral hydrogen, using this intergalactic gas as a matter tracer of the underlying density of matter has proven a very effective way to probe BAO features in areas that cannot be reached by galaxy surveys. Therefore, we test ConKer's applicability to this more continuous matter density tracer by applying it to data from the extended Baryon Oscillation Spectroscopic Survey and the Dark Energy Spectroscopic Instrument. We obtain measurements of 2pcf and compare it to the standard algorithm used in the field, Picca. We find that preliminary results show ConKer is successful at computing the 2pcf for continuous matter distributions, thus providing an alternate and efficient calculation of the 2pcf in intergalactic gas.

Spectroscopic Search for Transients using the Dark Energy Spectroscopic Instrument

Edmund Sepeku, University of Rochester

Transient phenomena such as supernovae are usually detected through image differencing, although they can be discovered and classified using their spectra. Traditional methods of classifying supernovae include the use of spectral template fitting and visually inspecting spectra. Unfortunately, these approaches are computationally or time intensive making them obsolete for the next generation of large scale galaxy redshift surveys such as the Dark Energy Spectroscopic Instrument (DESI), which observes > 50,000 spectra per night. Our approach is to change the problem to one of image recognition through the use of neural networks. By transforming galaxy spectra into 2D images, we can train neural networks to quickly identify and classify transients in those galaxies using the output of the DESI spectroscopic pipeline. Although there is room for improvement, the approach is promising with over 100 supernovae detected and classified in the first year of DESI's operation.

SESSION IB. QUANTUM OPTICS AND CONDENSED MATTER PHYSICS

Hong-Ou-Mandel Interference with a Fibered Beam Splitter

Nicholas S. DiBrita, Colgate University

Interference phenomena are at the heart of quantum theory. An example of quantum interference occurs when two indistinguishable photons simultaneously arrive at a beam splitter: the photons interfere, resulting in both photons exiting from the same output of the splitter. This is referred to as the Hong-Ou-Mandel effect, first experimentally realized in 1987 by Chung Ki Hong, Zheyu Ou, and Leonard Mandel. It is interesting from a fundamental physics perspective, but also has a variety of applications in quantum metrology and information science. We designed and assembled an apparatus capable of reproducing this effect using a fibered beam splitter, which removes a significant portion of the free-space alignment procedure. Our setup also allows us to easily change the relative arrival times and the polarization of the photons, thus altering the size of the interference effect. Here I report on the observation of the characteristic Hong-Ou-Mandel dip with this new setup.

Quantum Mueller Polarimetry

ChanJu (Zoe) You, Colgate University

Our work focuses on a new technique called Quantum Mueller polarimetry. We use entangled photon pairs to obtain the Mueller matrix of various samples. The nonlocal Mueller technique that we perform provides a demonstration of the quantum nonlocality of entanglement. Currently, we are further consolidating our method of Quantum Mueller Polarimetry through experiments with various optical elements such as polarizers, quarter wave plates and half wave plates.

Demonstration of phase transitions using a 1D longitudinal mechanical topological insulator

Parker Fairfield, Luke Thatcher, Juan Merlo-Ramírez, Vassar College

We constructed a mechanical model of a metallic spring to demonstrate the properties of a one-dimensional Su-Schrieffer-Heeger (SSH) model of topological insulators. In our model, the spring propagates longitudinal waves and was shown to demonstrate phase transitions between the insulator, conductor, and topological insulator phases of the SSH model. The former was done by changing the spring constant between atoms within sites. A clear edge state was also shown in the topological insulator phase. In addition, these findings are supported by a mathematical model derived from the mechanics of harmonic oscillators. Our device is simple to construct and easy to understand. It is a great tool to demonstrate an important aspect of condensed-matter physics research to undergraduate students.

Annealing and Characterization of Zinc Doped Niobium Oxide for Neuromorphic Computing Applications

Emma Sargent, Alex Mesiti, Nicole Zhe, Andrew Rowley, James Michels, Zachary Robinson, Karsten Beckmann, Nate Cady, Timothy Walters, Hans Cho, Alex Kozen, SUNY Brockport

Deposition of niobium dioxide on silicon wafers is a potential post-transistor application for memristors as part of a neuromorphic computing architecture. Since pure niobium dioxide (NbO2) has a crystallization and insulator to metal transition (IMT) temperature that exceeds the thermal budget of current semiconductor processing techniques, doping NbO2 to reduce both crystallization and IMT temperatures is essential for it to become usable. Through numerous tube furnace anneals with systematically varied temperatures and times, we show that a 10 percent zinc doped sample lowered the NbO2 crystallization temperature by an average of 75°C, lowering the temperature range in which crystallization is observed from 825-900°C to 750-825°C, along with a decrease in requisite annealing time. The crystallization patterns were first observed through optical microscope imaging, and confirmed with XPS and Raman Spectroscopy. Preliminary optical reflectivity measurements performed in an ultra-high vacuum system in an effort to measure the IMT will be discussed.

SESSION II. POSTER SESSION

An Experiment to Simulate Trapping and Detection of Radioactive Isotopes Produced in ICF Implosions

Adam E. Brown, Micah J. Christensen, Micah K. Condie, Mark Yuly, James G. McLean, Stephen J. Padalino, Chad J. Forrest, Thomas C. Sangster, Sean P. Regan, Houghton College

It may be possible to measure the low energy nuclear cross sections of light ion reactions by trapping the reaction products from an Inertial Confinement Fusion (ICF) implosion and detecting their beta decays. To test this idea, an "exploding wire" experiment was designed to simulate the expanding gas released in an ICF event. A copper plated tungsten foil was inserted into a vacuum chamber and activated with a deuteron beam via ^{65}Cu(d, p)^{66}Cu. A current pulse through the tungsten then vaporized the copper to create an expanding radioactive gas, simulating the gas behavior in the ICF target chamber following the laser shot. Attempts were made to capture some gas and detect the ^{66}Cu beta decays using two trap designs, one using a getter and the other a turbopump. Both designs used the Short Lived Isotope Counting System (SLICS), consisting of plastic scintillator phoswich detectors and fast electronics, to identify and count the beta particles. Funded in part by a grant from the DOE through the Laboratory for Laser Energetics, and by SUNY Geneseo and Houghton College.

Producing the ^{2}H(d,n)^{3}He reaction with the Houghton College Cyclotron

Andrew Hotchkiss, Joshua Bowman, and Mark Yuly, Houghton College

The Houghton College Cyclotron accelerates ions inside of a 17 cm inner diameter evacuated aluminum chamber placed between the poles of a 1.2 T electromagnet. Very low pressure gas allowed into the evacuated chamber is ionized by electrons coming from a filament. Inside the chamber, a high voltage RF signal applied to a "dee" shaped electrode accelerates the ions each time they are between the dee and a grounded "dummy dee", resulting in a spiral path because of the magnetic field. The cyclotron has successfully accelerated hydrogen, helium and most recently, deuterium. The deuterons were allowed to implant into a copper target, where they reacted via ^{2}H(d,n)^{3}He to produce neutrons which were detected using a plastic scintillator outside the vacuum chamber.

Statistical Effects of Synthetic Template Mismatch with Model DEIMOS Observations
Christos Kakogiannis, Union College

High-precision kinematics of individual stars in Milky Way satellite galaxies and globular clusters is crucial for studies of galaxy formation, cosmology, alternative gravity models, and dark matter. We tested a rigorous method that matches model DEIMOS observations of such targets with synthetic template spectra that deduces the radial velocities and [Fe/H] abundances. We added noise to create a model spectrum with SNR = 30, fitted templates with different parameters to it, and calculated the best-match velocity and the goodness of the fit. We confirmed that the best fits occur for templates that are close in parameter space to the model spectrum, and that the fits get worse the further away the templates are from the model spectrum. Within a window of $\sim\pm 1500$ K from the model spectrum, the bias in inferred velocity increases at a rate of roughly $\lesssim 0.5$ km/s per 1000 K , but stays below the DEIMOS resolution. We conclude that the method does not introduce a bias to the inferred velocity larger than $\sim$ 30% of the instrumental resolution and that the uncertainty is dominated by the resolution, suggesting that the step size in our parameter space was well chosen.

Enabling Unsupervised Learning in a Josephson Junction Neural Circuit
Eric Matt, Colgate University

We explore the dynamics of a simple simulated neural circuit with Josephson Junction-based neural elements that closely mimic the behavior of biological neurons, synapses, and axons. The high level of biological realism allows us to levy spike timing dependent plasticity to enable unsupervised, Hebbian learning. We identify five unique learning states and explore how changes in initial conditions affect long-term steady state solutions of the circuit. We also study a persistent structure and conclude that it is a co-dimension two bifurcation.

Using a Numerical Model to Investigate the Analytical Limits of Thermal Diffusion
Jamie Woodworth, Ithaca College

Our project explores the thermodynamics of heat transport through a thin metal rod, which is governed by the one-dimensional thermal diffusion equation. This equation has an analytical solution only when you assume a thin metal rod of infinite length where heat is applied instantaneously to an infinitesimal segment of the rod. We created a numerical model of the diffusion equation in order to investigate the situations where the analytical solution breaks down. Our model agrees with the analytical solution under the analytical conditions and can be extended to conditions that violate analytical assumptions, including finite rod lengths, long heat pulses, and heat-sunk and free-floating rods. In addition, the numerical model can investigate situations that are difficult to replicate experimentally, such as testing various heater sizes. Our results show that, when compared to the analytical solution, the numerical simulation more accurately models thermal diffusion in metal rods.

An Ambient Air Scanning Tunneling Microscope to Study the Surfaces of Thin Metal Films
Joshua Wilson and Brandon Hoffman, Houghton College

An ambient-air scanning tunneling microscope (STM), based on the design by Daniel Berard, is being designed and built at Houghton College to study the surfaces of thin metal films. An STM uses a quantum mechanical tunneling current to create a topographical image of the film's surface with atomic resolution. This will be performed by supplying a small bias voltage to the film, ~1 V, and bringing an atomically sharp metal tip close to the film via a set of three stepper motors that will move the tip in small increments until it is in tunneling range. The tip will then scan across the surface of the film. The tip will be moved in three dimensions by supplying voltage to specific quadrants of a piezo buzzer. A constant tunneling current will be maintained during the scan by moving the tip up or down. Therefore, a plot of the height of the tip vs. its horizontal position will be a topographical image of the film's surface. All of this will be controlled via a Teensy and Processing sketch. A dual stage structure to contain the STM is being produced. This structure will use both springs and eddy current damping to isolate the system from external mechanical vibrations.

Deep Sky Astrophotography & Detecting the Properties of an Eclipsing Binary-Star System Using Differential Transit Photometry
Marvin Lopez and Richard McCoy, Hamilton College

Last summer, our goal was to equip the Peter's Observatory with the capabilities to detect exoplanets—planets that orbit stars other than our own. To do this, a number of upgrades to our telescope's pipeline were required, such as changes to the methods used to process images of the sky.

A New Evaporator for the Houghton College Deposition Chamber
Matthew Bowman and Brandon Hoffman, Houghton College

A new evaporator has been designed and constructed to improve upon the Houghton College high vacuum deposition system. The system, used to systematically deposit thin metal films on a Si substrate while at a 10^{-6} Torr, utilizes a student-designed power source capable of floating a tungsten filament at -4 kV to achieve thermionic emission. These emitted electrons heat the graphite crucible and evaporate the contained metal. The base and crucible holder of the new design have a diameter of 5 cm and are mounted directly to a 5-pin high voltage electrical feedthrough. This allows the entire evaporator to be easily removed for the replacement of filaments and target material. The new iteration holds three crucibles, which provides the ability to deposit multiple metals at once. It also utilizes a tantalum crucible holder, which permits much higher crucible temperatures to evaporate metals with low vapor pressures.

Phase Unwrapping for Interferometry using a Radial Basis Function Neural Network

Aidan Bachmann and Pierre Gourdain, University of Rochester

Unwrapping interferometry phase is a computationally expensive problem for large datasets. Several methods already exist for dealing with such problems. Poisson solvers and discrete cosine transforms utilize a global approach, unwrapping the phase all at once. Kalman filters employ a local approach, unwrapping the phase one pixel at a time while using the phase of the previous pixel to ensure the unwrapping is continuous. However, due to their point-by-point treatment of the unwrapping, these methods produce error as phase differences and noise level increase. In order to address this issue, a global method has been developed which utilizes a radial basis function neural network (NN) to reconstruct the unwrapped phase, as well as its first and second derivatives. Starting with the initially wrapped phase, the NN is first trained to match the second derivative of the phase, followed by the first derivative of the sine and cosine of the phase. The last step trains the NN to match the sine and cosine of the phase. After this final step, the output layer simply holds the unwrapped phase and its two successive spatial derivatives.

Unsupervised Learning in Josephson Junction-Based Spiking Neural Networks

Raluca Ghilea, Colgate University

Computational requirements for complex neural networks are rapidly outpacing the improvements in compute performance as described by Moore's Law. Unsupervised learning in spiking neural networks (SNNs) is an alternative to traditional supervised learning in artificial neural networks (ANNs) and promises increased performance on complex problems. To address the high energy consumption of transistor-based networks, Josephson junctions (JJs) have been shown to be great candidates for spiking neurons given their very fast dynamics and low-temperature operation. In this paper, we will propose a proof of concept for a JJ-based SNN classifier. Using Spike-Timing- Dependent Plasticity (STDP) as the unsupervised learning approach, we design a model that can classify digits encoded using only 7 pixels. We develop the network architecture, input encoding, training, classification, and testing algorithms and explore multiple approaches to obtain an optimal classification. Our goal is to show the applicability of unsupervised learning in JJ-based SNNs given the computational benefits and energy efficiency of such a network.

Synthesizing Iron Oxide Nanoparticles for Water Purification
Ryan O'Connor, Sam Lotemple, Dr. Kristen Repa, SUNY Brockport

When it comes to water purification, one of the most widespread methods of eliminating bacteria and microbes is chlorination. 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 synthesized 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. We used three different procedures to create these iron oxide nanoparticles, chemical co-precipitation, thermal decomposition, and electrochemical synthesis. While all three succeeded in synthesizing iron oxide nanoparticles, chemical co-precipitation has the highest particle yield and ease of reaction, while thermal decomposition generally creates more uniformly sized and shaped particles. The particles are currently being characterized to ensure appropriate size, shape, and crystallinity. Once we have the results, we can optimize synthesis, then begin testing which size and shape of particles remove contaminants the best; this will be done through a controlled study on the removal of e. coli from water samples.

Creating an Interactive Simulation for Rotating Reference Frames
Ted Mburu, Antara Sen, Ithaca College

The motion of non-inertial reference frames and the forces involved in understanding them (Coriolis and centrifugal forces) are challenging concepts for introductory and advanced mechanics students. Predicting trajectories of an object due to fictitious forces is another challenge for students. This discomfort for students is exacerbated by the complex interaction between the Coriolis and centrifugal forces. An established way of presenting all of this new material to students has been through the use of apparata that are tedious to build. We are building an interactive simulation of the traditional apparatus that many students may find helpful when trying to understand the motion of objects in non-inertial reference frames. Students can change both the velocity of an object and the angular velocity of the reference frame it is viewed in and then view a real-time, side-by-side comparison of the object in a rotating and stationary reference frame. The simulation was built in JavaScript, so it will run on most browsers on a computer or mobile device.

Simulating Low Temperature Detector Pulse Streams and Developing Edge Triggers
Timothy R. Ockrin and Katrina E. Koehler, Houghton College

Low Temperature Detectors (LTDs) such as Metallic Magnetic Calorimeters are very high resolution (~1000 resolving power [1]) detectors that can be used to accurately measure the decay energy to determine the probability of electron capture from different orbitals. It has been found that the streamed pulse data from these detectors contain discontinuities that may occur during a pulse corresponding to a single electron capture event. If this is the case, the pulse must be cut from data analysis. Discontinuities may also be associated with detector response changes, affecting achieved resolution. In this research, pulse streams with discontinuities are simulated. The performance of various triggering algorithms on the simulated data are compared to maximize the accuracy of detecting discontinuities and their arrival times. These algorithms will be used on experimental data to determine the time of occurrence of each discontinuity in that data. The timestamps of the discontinuities will be compared to data on the environmental and detector conditions in the LTDs to find and eliminate the factors that caused the discontinuities.
[1] K.E. Koehler. "Low Temperature Microcalorimeters for Decay Energy Spectroscopy". Appl. Sci. 2021, 11, 4044.

Unsupervised Learning In Josephson Junction Circuit
Will Friend, Colgate University

Unsupervised learning networks are a form of neural networks that require no training, as their synaptic weights are adjustable rather than predetermined. In this paper we show a circuit design that acts as an analog to a neuron firing action potentials into a synapse from two separate axons. We study the time dependence of two pulses entering a synapse and whether or not it "learns" (becomes stimulated or not). Our circuit is constructed using the superconducting circuit element Josephson Junctions. Through simulations and real time experiments at 4.2 Kelvin, we show that when the delay between pulses is changed, our circuit demonstrates Spike Time Dependent Plasticity for learning, as well as the ability to learn unsupervised (synaptic weights changing over time rather than being selected manually).

SESSION IIIA. ASTRONOMY AND ASTROPHYSICS

Interior Luminosity Curves of Cepheid Variables

M. Manno, L. Samson, S.Kalici, H. Randall, D. Podos, N. Proietti, AJ Chalmers, S. Das, E. Bellinger, A. Bhardwaj, S. Kanbur, SUNY Oswego

We compute a grid of radially pulsating classical Cepheid models at full fundamental mode amplitude covering a wide range of periods. We compute these models using four different theories of turbulent convection and examine the differences in luminosity light curves as a function of depth in the star. Our aim is to determine differences produced by the four different theories of turbulent convection and determine where in the star quantitative features of the surface light curve structure are determined.

Linearized Stellar Pulsation Calculations for 3 Types of Variable Star

H. Randall, A. Chalmers, N. Proietti, S. Kalici, M. Manno, D. Podos, S. Kanbur, E. Bellinger, S. Das, A. Bhardwaj, SUNY Oswego

By using the state-of-the-art 1D hydrodynamic radiation code, MESA/RSP, we model three classes of variable stars. A robust grid of models is run for each of the three classes (RR Lyraes, Classical Cepheids, and Type II Cepheids). Each grid of models is run with four theories of time-dependent convection, labeled A, B, C, and D. For these calculations, RSP linearizes the equations of momentum and energy, and produces results in the first ten modes of the normal mode spectrum. We plot every model that produces a positive growth rate on a Color Magnitude Diagram (CMD) and will compare the theoretical results to observational data.

Applying ML Methods to blc1: Breakthrough Listen's First Signal-of-Interest

Zach Yek, Sofia Sheikh, Bryan Brzycki, Peter Ma, Dominic LeDuc, Matt Lebofsky, Vishal Gajjar, Steve Croft, SUNY Fredonia

The detection of life beyond Earth is an ongoing scientific endeavor, with profound implications. One approach, known as the search for extraterrestrial intelligence (SETI), seeks to find engineered signals (hereafter ‘technosignatures’) that indicate the existence of technologically-capable life beyond Earth.

Decomposition of Galactic Rotation Curves

Yifan Zhang, University of Rochester

We decompose the rotation curves of disc galaxies to study the matter content of the universe. Using the newly released data from SDSS MaNGA DR17, we fit the rotation curves of more than 3000 disc galaxies. Our model decomposes the mass of each disc galaxy into three components: a central bulge, a stellar disk, and the surrounding dark matter halo. With existing physical models and statistical methods, we obtain the best fitting parameters for each of the mass components that together, best fit the Ha gas velocity maps of the galaxies. We study three models describing the mass profile of the dark matter halo of galaxies: Isothermal, NFW, and Burket. Each model performs well in some samples of galaxies while failing in others. We investigate the differences in the galaxies that are best fit by one of the models to better understand the distribution of dark matter in different galaxies.

SESSION IIIB. NUCLEAR AND PARTICLE PHYSICS / INSTRUMENTATION & EXPERIMENTAL TECHNIQUES

Observing Monoenergetic KDAR Neutrinos in the ICARUS Detector

Joseph Vargas, SUNY Fredonia

When a positively charged kaon particle decays at rest, a muon and monoenergetic muon neutrino are produced roughly two-thirds of the time. KDAR (kaon - decay at rest) neutrinos have a constant energy of 236 MeV, and are one of the few viable tools that could be used to probe liquid Argon nuclei in ICARUS. When the incoming KDAR neutrino direction is known, both the momentum and energy transfer to the Argon nucleus can be determined by the kinematics of the outgoing muon. The NuMI beamline hadron absorber is an excellent source of KDAR neutrino production. The feasibility of identifying KDAR neutrinos in ICARUS is studied with simulations. Backgrounds due to decays in flight in the beamline are found to be dominant. A hypothetical special run with the NuMI target removed is considered. Backgrounds are considerably reduced in this configuration. Nevertheless, due to low angular resolution, proton - air collisions in the target hall, and proton - helium collisions in the decay pipe, further discrimination between KDAR signal and background was determined to be ultimately un-achievable given current experimental setups. This project was supported in part by NSF award PHY-1757062.

Deuterium-Deuterium Fusion in the Houghton College Cyclotron

Joshua Bowman, Andrew Hotchkiss and Mark Yuly, Houghton College

The Houghton College Cyclotron is a miniature particle accelerator that uses two “dee” shaped hollow electrodes, of 15.6 cm diameter, to accelerate ions across a gap with an alternating RF potential difference of a few thousand volts. As an ion accelerates, an up to 1.2 T magnetic field keeps it on a circular path that spirals outward, allowing the ion to be accelerated multiple times using the same electric potential. In this experiment, deuterium was ionized by electrons from a filament and the deuterons were accelerated, with a beam current of about 20 nA to an approximate energy of 4.8 keV, into a copper target at a radius of 5.54 cm where they embedded themselves. Later deuterons striking the embedded deuterons caused the $D(d,n)^3He$ reaction which produced neutrons. A plastic scintillator detector counted for 50 minutes the neutrons (or other radiation) that penetrated the chamber walls, both with and without heating the filament. An increase of 7913±587 counts total (or 158±12 per minute) was detected when the filament was turned on. This is a significant milestone as it may be the first nuclear reaction produced using the Houghton College Cyclotron to be detected.

The Houghton College Interferometer
Noah Klein and Brandon Hoffman, Houghton College

At Houghton college, a phase stepping interferometer is currently under development for the purpose of studying the stress in thin metal films. Light from a 3 mW, 635 nm laser diode is separated into two 7.5 cm diameter beams. One reflects off a thin film sample while the other reflects off a reference mirror. The two reflected beams recombine to produce an interference pattern. On the reference mirror, piezoelectric ceramics are attached to move the mirror and create a stepped phase change of the interference pattern. A camera then captures a set of patterns, which are converted into a topographical image of the film. LabVIEW code was developed for control of the reference mirror and analysis. The topography of the thin film allows for the curvature of the film to be determined, which is necessary in calculating the film stress. To isolate the system from external mechanical vibrations, an Eddy Current damping table was created, along with a housing unit and rubber feet.

Construction and Calibration of the Houghton X-ray Diffractometer
Nathaniel Davie and Brandon Hoffman, Houghton College

A Bragg-Brentano theta-2theta x-ray diffractometer (XRD) was advanced towards completion in construction at Houghton College as a means to measure the unit cell shape and crystal lattice spacing of thin films and small, lab-grown crystals. XRD uses angles of diffracted characteristic x-rays to measure the distance between lattice layers. Analysis makes use of Bragg's Law, which relates the crystal lattice spacing to the angle of constructive interference of the reflected x-rays. The Houghton XRD has a 40 kV, 25 mA x-ray source. Stepper motors rotate the sample and Vernier Radiation Monitor 0.011° per step. Positions are monitored by encoders. Arduino and Processing sketches have been developed to control the system. A preliminary test using a Si-100 substrate was able to successfully produce a pronounced peak at its known diffraction angle. The analysis conducted at Houghton College by the XRD will offer a range of data useful in studying the mechanical, physical, and electrodynamic properties of thin films, resulting in optimized application of the thin films themselves.

SESSION IVA. ASTRONOMY AND ASTROPHYSICS

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

Colin Steiner, Ka-Wah Wong, Dacheng Lin, Jimmy Irwin, 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.

Predicting the IceCube Response to Neutrino Bursts from Core Collapse Supernovae

Xinyue Wu, University of Rochester

Neutrinos carry away 99% of the energy of core collapse supernovae. The IceCube Neutrino Observatory is capable of measuring the burst of ~10 MeV neutrinos from a supernova near the Milky Way. The arrival of neutrinos at Earth precedes the observation of optical emission from the supernova explosion by minutes to days, and therefore serves as a reliable alert for optical telescopes. However, there are many factors that affect the expected signal significance. To predict the response of IceCube to core collapse events, various models are tested. We have integrated SNEWPY, a simulation package that contains a large number of standard supernova neutrino luminosity models, with the IceCube response analysis package ASTERIA. The result of the simulations shows that the current generation of the IceCube detector is sensitive to a wide range of models at high significance for all supernova explosions occurring in the Milky Way.

Measuring Peculiar Velocities with the Dark Energy Spectroscopic Instrument using the Tully-Fisher Relation

Navya Uberoi, University of Rochester

Since Hubble's survey of galaxy redshifts in the 1920s, it has been widely accepted that the universe is expanding in all directions. However, due to a relative overdensity of matter in certain regions in the universe, some galaxies exhibit intrinsic motion relative to the isotropic expansion rate governed by Hubble's Law. These motions, known as peculiar velocities, can provide information about the large-scale distribution of matter, set constraints on the growth rate of cosmological structure, and provide an estimate of Hubble's constant. One way of measuring peculiar velocities is using the Tully-Fisher relation, a scaling law that correlates the luminosities and maximum rotational velocities of spiral galaxies. Using optical spectra of galaxies in the Coma cluster measured by the Dark Energy Spectroscopic Instrument (DESI), we calibrate the Tully-Fisher relation, which we then use to determine the peculiar velocities of galaxies in the DESI Early Data Release by quantifying the scatter around the empirical relation. We compare our calibrated Tully-Fisher relation with existing Tully-Fisher calibrations and discuss the systematics of this distance method.

SESSION IVB. BIOLOGICAL PHYSICS AND OTHER

Mechanosensitivity of Epithelial Layer Maturation
Joseph Glichowski, University of Rochester

Epithelial tissues perform critical functions such as protection, absorption, and filtration at organ boundaries. These tissues are commonly comprised of sheets of cells (layers) that are one cell thick. Epithelial structure and the ability of an epithelial layer to function are tightly linked.

Mobile Observations of Major Methane Sources in New York State
Jacob Cooney, Ithaca College

Current and future global warming is impacting the world at an accelerating rate. In this research, mobile observations were conducted around central New York at multiple landfills, dairy farms, natural gas stations, and a salt mine to better locate and quantify methane sources. Mobile observation with analyzers mounted in a car or carried in a backpack allows for quick and cost effective analysis of methane sources. Each site was encircled and mapped to quantify how much methane is being emitted. Wind speeds were also recorded, which allowed a mass balance approach to be used. Differences between upwind and downwind concentrations are assumed to come from the source and an emission rate can be estimated when coupled with wind speeds. Using our surface observations we estimate emissions from a dairy farm to be approximately one quarter of the rate calculated by an aircraft-based emission estimate using the same methodology. Estimating sources from within the farm, including dairy cows and manure storage, with closer observation triples our estimate showing the importance of proximity. Encircling the farm in its entirety placed the plume over our sensors. Similarly, our surface measurements only report a fraction of emissions from a large central New York landfill.

Annealing of Titanium Doped Niobium Dioxide

Alex C. Mesiti, Emma G. Sargent, Zachary R. Robinson, Carl A. Ventrice Jr., Karsten Beckmann, Nate Cady, Matthew Sullivan, Tim Walters, Hans Cho, Alex Kozen, SUNY Brockport

Niobium Dioxide (NbO_2) is a promising material for future-generation computer architectures. NbO_2 undergoes an insulator to metal transition (IMT) that could be used as a switch for certain neuromorphic computing architectures. However, the IMT occurs at a high temperature (around 800°C), and only in fully crystallized material. A promising solution to these problems is to dope the NbO_2 with other materials in order to both reduce the IMT, and also to encourage crystallization. In this work, titanium doped niobium oxide (NbOx) samples were deposited by collaborators using techniques that result in amorphous films. We then annealed the samples, along with undoped NbOx control-samples, at temperatures ranging from 800 – 1000°C for times ranging from 20 - 60 minutes. These samples showed no temperature changes with crystallization when compared to the undoped samples. With this data, it was concluded that titanium doped NbO_2 does not lower crystallization temperature. Our current work is attempting to measure the effect of the titanium doping on the IMT through the use of optical transmission in an ultra-high vacuum chamber.

Characterization of niobium-oxide devices

Paul Suflita, SUNY Brockport

Niobium-oxide materials have been increasingly studied due to their potential use as selectors for brain-like sensors, and for their future use in chemical detectors. We studied the characteristics of NbOx-based electronic devices before and after crystallization anneals at temperatures ranging from 500°C to 1000°C. As-deposited, the NbOx material is amorphous. We hope to find annealing conditions that allow for full crystallization without damaging the circuit-elements that are deposited beneath the NbOx. Optical imaging and Raman spectroscopy are the primary characterization techniques we are using in this study. Initial results have found that temperatures up to 800°C in an argon ambient resulted in device structures likely surviving, but without achieving full crystallization. Prior work suggests crystallization will be achieved at 950°C. We will perform several more anneals, and look forward to presenting our latest data at RSPS, which may include electronic testing after our anneals have been completed and verified.

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