

## CONTRIBUTED POSTER ABSTRACTS

### *Heightened figure of merit for lithium-doped copper(I) iodide thin films*

Alexander Brodie, Gabrielle DeSantis, Jennifer Gunning, Nancy Huang, Jake Kaufman, Mairead McCarran, Jordan Shaked, and Marissa R. Civic\*  
Freshman Research Immersion, Binghamton University, Vestal, NY

There are increasing demands for the development of high performance optoelectronic devices comprised of cost effective, abundant materials and facile fabrication methods. Research has been conducted to enhance the performance of transparent conductors (TCs), such as copper(I) iodide (CuI), to increase the range of applications in optoelectronic devices. These applications include solar cells, light emitting diodes, and flat panel displays. The potential of CuI to be more competitive against current applications in transparent electronics depends on the ability of the p-type semiconductor to reach high room temperature conductivity values and maintain high transparency values. This research focuses on doping CuI with various concentrations of lithium to manipulate conductivity values, as well as fabricating CuI thin films. Figure of merit (FOM), which measures the ratio of electrical conductivity to the visible absorption coefficient, will be used to numerically represent the transparency and conductivity of the doped CuI thin films relative to other p-type TCs.

### *Heightened figure of merit for lithium-doped copper(I) iodide thin films*

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There are increasing demands for the development of high performance optoelectronic devices comprised of cost effective, abundant materials and facile fabrication methods. Research has been conducted to enhance the performance of transparent conducting electrodes, such as copper(I) iodide (CuI), to increase the range of applications in optoelectronic devices. These applications include solar cells, light emitting diodes, and flat panel displays. The potential of CuI to be more competitive against current applications in transparent electronics depends on the ability of the p-type semiconductor to reach high room temperature conductivity values and maintain high transparency values in the visible spectrum. This research focuses on doping CuI with various concentrations of lithium to manipulate conductivity values, as well as fabricating CuI thin films of various thicknesses in a layer-by-layer approach via spin coating and annealing. Highly conductive and transparent CuI:Li films have been fabricated using a cost effective and scalable manufacturing procedure. X-ray diffraction (XRD), UV-Vis spectroscopy, four point probe electrical measurements are used to characterize the films as well as determine their crystallinity, transparency, and sheet resistance. Figure of merit (FOM), which measures the ratio of electrical conductivity to the visible absorption coefficient, will be used to numerically represent the transparency and conductivity of the doped CuI thin films. The figure of merit values of the films will be examined relative to other p-type transparent conductors.

## ***Equilibrium models of relativistic stars with differential rotation and toroidal magnetic fields***

Logan Carpenter & Eric Hirschmann  
Brigham Young University - Idaho & Brigham Young University

We construct equilibrium models of strongly magnetized neutron stars in general relativity under the assumptions of axisymmetry and stationarity. The matter is represented by a magnetized fluid in the ideal MHD approximation and incorporates differential rotation and a toroidal magnetic field. We solve for these equilibrium states using a numerical scheme similar to the self-consistent field method. We construct as an initial guess a TOV star, add differential rotation and subsequently include the magnetic field. We then explore the parameter space of these equilibrium solutions looking for maximum mass, magnetic field strength, and energy distribution in the star.

## ***Temporal Diffraction Signal Analysis of C. elegans Locomotion***

Cheris Congo; Miranda Hulsey-Vincent; Dr. Jenny Magnes; Vassar College Physics and Astronomy Department

Current methods of analyzing microorganism movement require time-consuming video analysis, omit subtle motion components, and often involve manual data entry, making it subjective to user errors. We place the microorganism in a laser beam and monitor light intensity at a point off center within the resulting diffraction. A *C. elegans* with a mutation that restricts its movement was used as a sample organism due to its anatomical symmetry. Diffraction patterns contain information about the nematode's shape and locomotion. To better understand basic dynamic elements, we approximated the worm's motion and shapes using periodically rotating and translating rectangular segments at different speeds and directions. Resulting frequencies present in the Fast Fourier Transforms were identified, analyzed, and quantified. Individual segments were rotated and translated at a rate that matched those of a *C. elegans*' structure, assuming constant motion. The summation of these segments resulted in a closely-packed periodic function, similar to a mutant *C. elegans*' active thrashing pattern.

## ***Rings of Molecular Line Emission in the Disk Orbiting the Young, Close Binary V4046 Sgr***

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David Wilner: Smithsonian Institution  
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Uma Gorti: SETI Institute (Mt View, CA)  
Valerie Rapson: Dudley Observatory (Schenectady, NY)  
Germano Sacco: Arcetri Observatory (Florence, Italy)  
Dave Principe: MIT (Cambridge, MA)

We present analysis of a suite of subarcsecond ALMA Band 6 (1.1 - 1.4 mm) molecular line images of the circumbinary, protoplanetary disk orbiting V4046 Sgr. The ~20 Myr-old V4046 Sgr system, which lies a mere ~73 pc from Earth, consists of a close (separation ~10 Rsun) pair of roughly solar-mass stars that are orbited by a gas-rich circumbinary disk extending to ~350 AU in radius. We summarize the insight into the physical and chemical

processes within this evolved protoplanetary disk that can be obtained from comparisons of the various emission-line morphologies with each other and with that of the continuum (large-grain) emission on size scales of tens of AU.

### ***Development and Automation of an Ultra-High Vacuum System for Synthesis of 2-Dimensional Materials***

Mayuka Sasaki<sup>1</sup>, Zachary Robinson<sup>1</sup>, Luke Nyakiti<sup>2</sup>

1 – SUNY College at Brockport Department of Physics

2 – Texas A&M Departments of Marine Engineering and Material Science Engineering

Graphene is a two-dimensional (2D) semi-metal consisting of a single layer of sp<sup>2</sup> hybridized carbon. Due to its interesting and unique electrical, optical, thermal, and mechanical properties, synthesis of high quality graphene is being studied by many research groups. One way to study graphene growth is in an ultra-high vacuum (UHV) chamber. In order to achieve UHV, the whole chamber needs to be heated to above 100°C for several days to desorb water and other molecules from the chamber's inner walls. To closely monitor the bakeout process, electronics were designed and custom software was developed. A LabView program now monitors the bakeout process, and a Python program analyzes the data and posts the chamber status to a website for remote monitoring. After the bakeout, graphene will be grown on C-face SiC with an e-beam heater. The primary characterization technique we plan to use is low energy electron diffraction.

### ***Fabrication of Reproducible Micro-Bridge Structures***

Zachary Johnson, Connor Murphy, and Michael Thompson

Grove City College

This research focuses on refining the processes necessary to form microstructures. Copper micro-scale bridge structures were made by electroplating copper into molds created by exposing AZ P4620 photoresist to light from a mercury lamp under various masks and rinsing with developing and etching solutions. The bridge structures are formed about 5 micrometers above the surface of a silicon wafer sputtered with a conductive layer of gold and an adhesion layer of either a copper or titanium. If the distance between the bridges and the wafers can be reduced to the scale of nanometers, it may be possible to observe a force between the surface of the wafer and the bridge due to the Casimir effect.

### ***CMOS-Memristor Implementation of Cellular-Automata Based Reservoir Computing***

Wilkie Olin-Ammentorp, Karsten Beckmann, Nathaniel Cady

SUNY Polytechnic Institute

Reservoir computing is technique in which a large dynamical system, such as a recurrent neural network, processes inputs, and develops a large set of complex responses from these inputs. A simple output layer is then used to filter these responses to find ones which are relevant to solving a certain problem. Cellular automata (CA) are discrete elements which can enter one of a number of different states based on the state of their neighbors. It has been demonstrated that even one-dimensional CA can create behaviors complex enough to serve as a computing reservoir. In this work, we present our 65nm CMOS implementation of a reservoir based on 1-D cellular automata, integrated with a memristive output layer. This will allow for fast, low-power learning on a monolithic circuit.

### ***New Algorithm Identifies Tidal Streams Oriented Along our Line-of-Sight***

Ziyi Lin, Heidi Jo Newberg, Paul Amy, Charles Martin, and Keighley Rockcliffe  
Rensselaer Polytechnic Institute

The known dwarf galaxy tidal streams in the Milky Way are primarily oriented perpendicular to our line-of-sight. That is because they are concentrated into an observable higher-surface-brightness feature at a particular distance, or because they tightly cluster in line-of-sight velocity in a particular direction. Streams that are oriented along our line-of-sight are spread over a large range of distances and velocities. However, these distances and velocities are correlated in predictable ways. We used a set of randomly oriented Milky Way orbits to develop a technique that bins stars in combinations of distance and velocity that are likely for tidal streams. We applied this technique to identify previously unknown tidal streams in a set of blue horizontal branch stars in the first quadrant from Data Release 10 of the Sloan Digital Sky Survey (SDSS).

### ***Development of an Efficient Model Extension Method with Application to Pancreatic Cancer Microenvironment***

Mit Patel (Vassar College); Adam Butchy, BS; Khaled Sayed, MSc, Natasa Miskov-Zivanov, PhD  
(University of Pittsburgh- Department of Electrical and Computer Engineering)

In this work, we are developing methods to automatically assemble intra-and inter-cellular models, and we are applying these methods to study the progression of pancreatic cancer *in silico*. We started with an initial baseline model that was created by manually identifying key components and interactions within and between tumor-associated macrophages and pancreatic cancer cells. Next, we extended the baseline model with interactions that were extracted from literature by automated reading engines and assigned confidence scores by epistemic values. Limitations set by underlying graph theory, however, restrict the approaches that can be utilized to efficiently extend the baseline model, as the number of potential extensions increases with the number of interactions extracted by reading. Therefore, our objective is to design and implement a practical approach to more efficiently and accurately extend the model with the automated reading outputs, while preserving or improving the biological validity and relevance of the model.

### ***Local Stellar Halo Substructure observed with Gaia and LAMOST***

Thomas Donlon, Cuihua Du, Heidi Jo Newberg, Hélio Perottoni  
Rensselaer Polytechnic Institute

We have combined Gaia proper motions with LAMOST radial velocities and distances to generate a catalog of several thousand stars with full phase space information. This dataset can be analyzed to find velocity substructure within the local Galactic halo from tidal streams or other phenomena characterized by moving groups. A method adapted from Helmi et al. (2016) to find these moving groups is presented, as well as a recently discovered moving group that may shed light on the origins of hypervelocity stars.

### ***Microscale Pattern Fabrication on PTFE through the Use of a Focused Electron Beam***

Seth Byard, Ryan King  
Grove City College, PA.

We have employed a focused electron beam from a Scanning Electron Microscope (SEM) to print microscale patterns, with details on the order of 10 micrometers, on polytetrafluoroethylene (PTFE, marketed as Teflon). We have investigated the efficacy of pre-coating the Teflon with gold and copper thin films, as well as the effects of

adjusting SEM parameters such as electron beam intensity, dose, and current. The present goal of this research is to create high-resolution (i.e., nanoscale) features, for which we can envision various interesting applications. In addition to the unique and intriguing nature of this process, we hope this work may aid our research group in their fabrication of micro-structures. The resolution of our microscale patterns is currently limited by the irregularities of the Teflon samples that we possess.

### ***Fabrication of Inorganic-Organic Bicomposite Thin Films of Strontium Titanate and Poly(3,4-ethylenedioxythiophene)***

Jeffrey Berling, Steve Blum, Collier Engel (Presenting), Brianna Hawkins, Matthew Krebs (Presenting), Tyler Rowe, Alexa Schaffer, and Marissa R. Civic\*

Freshman Research Immersion, Binghamton University, Vestal, NY

The electrodeposition of poly-(3,4 ethylenedioxythiophene) (PEDOT) via strontium titanate (SrTiO<sub>3</sub>) thin films on fluorine-doped tin oxide (FTO) was explored. Spin coating was used to fabricate the SrTiO<sub>3</sub> thin films, which were then used as the working electrode in a three-electrode cell for electrodeposition. Cyclic voltammetry was used to oxidize the SrTiO<sub>3</sub> film, which is insulating over its neutral potential. Upon oxidation, the film becomes conductive, driving electron transfer from the monomer in solution to the SrTiO<sub>3</sub> mediating electrochemical polymerization. Confirming the SrTiO<sub>3</sub> mediative process was investigated. The SrTiO<sub>3</sub> films were characterized with XRD, CV, and EIS. EIS was used to analyze the electrical properties of the titanate. Electrodeposition of PEDOT over the SrTiO<sub>3</sub> films was investigated in different pH solutions to verify mediation. Mediated electrodeposition of conductive polymers on inorganic films might provide solid-state photovoltaics with new hole-transport medium fabrication methods.

### ***First-Principles Study of Phonon Anharmonicity in Atomically-Thin Black Phosphorus***

Andrew Cupo, Damien Tristant, and Vincent Meunier  
Rensselaer Polytechnic Institute

Black phosphorus (BP) consists of anisotropic puckered layers held together by long-range van der Waals forces, which allows for the isolation of single-layers. This material is of interest due to its semiconducting band gap which remains direct independent of the number of layers, as well as its high carrier mobility. It was shown experimentally that the Raman active modes Ag<sub>1</sub>, B<sub>2g</sub>, and Ag<sub>2</sub> have frequencies which downshift with increasing temperature. In this work we study this phenomenon for the single-layer using first-principles density functional theory (DFT) calculations. To model the temperature-induced shift of the phonon frequencies, we carry out ab initio molecular dynamics simulations with varied temperature. The normal mode frequencies are located at the peak positions in the power spectrum, which is calculated as the magnitude of the Fourier transform of the total velocity autocorrelation. In general we obtain frequency downshifts with increasing temperature in agreement with experiment.

## ***Measurement of sensitivity versus electron dosage of buried semiconductor features via backscattered electron simulations***

Maseeh Mukhtar and Brad Thiel  
SUNY Polytechnic Institute

In fabrication, overlay measurements of semiconductor device patterns have conventionally been performed using optical methods. Beginning with image-based techniques using box-in-box to the more recent diffraction-based overlay (DBO). Alternatively, use of SEM overlay is under consideration for in-device overlay. Two main application spaces are measurement features from multiple mask levels on the same surface and buried features. Modern CD-SEMs are adept at measuring overlay for cases where all features are on the surface. In order to measure overlay of buried features, high voltage SEM (HV-SEM) is needed. Gate-to-fin and BEOL overlay are important use cases for this technique. A JMONSEL simulation exercise was performed for these two cases using 10 nm line/space gratings of 5 lines of graduated increase in depth of burial. Backscattered energy loss results of these simulations were used to calculate the sensitivity measurements of buried features versus electron dosage for an array of electron beam voltages.

## ***Measuring Cosmic Velocity Field Evolution with a Novel Millimeter-wave Spectrometer***

Victoria Butler, Mike Zemcov  
Rochester Institute of Technology

The Tomographic Ionized Carbon Mapping Experiment (TIME) is a novel millimeter-wave imaging spectrometer designed to make the first high speed kinetic Sunyaev-Zeldovich (kSZ) effect survey. TIME is a heritage instrument in that it improves upon several previous devices attempting to measure this effect. Its most important advances include atmospheric monitoring channels for noise reduction, and measurements in a waveband of roughly 200-300 GHz, where the tSZ signal is at a null and the kSZ signal is at a peak. This high significance kSZ signal can then be used to compute the peculiar velocities of hundreds of galaxy clusters, and lead to a mapping of the cosmic velocity field at various epochs. This also correlates to the cosmic gravitational field, and is a direct tracer for the effect of dark matter on large scale structure evolution.

## ***PIXE Analysis on Artificial Turf***

Skye Conlan, Michael Vineyard, Scott LaBrake, Sajju Chalise, Zack Porat  
Union College

There has been debate regarding the use of crumb rubber infill on artificial turf fields due to the potential presence of heavy metals and carcinogenic chemicals. We performed Proton-Induced X-Ray Emission (PIXE) analysis of artificial turf infill and blade samples collected from high school and college campuses around the Capital District of NYS to search for potentially toxins. Crumb rubber pellets were made by mixing 1g of rubber infill and 1g of epoxy. The pellets and the turf blades were bombarded with 2.2 MeV proton beams from a 1.1-MV tandem Pelletron accelerator in the Union College Ion-Beam Analysis Laboratory and x-ray energy spectra were collected with an Amptek silicon drift detector. We analyzed the spectra using GUPIX software to determine the elemental concentrations of the samples. The turf infill showed significant levels of Ti, Fe, Co, Ni, Cu, Zn, Br, and Pb. The highest concentration of Br in the crumb rubber was 1500 +/- 100 ppm while the highest detectable amount of Pb concentration was 110 +/- 20 ppm. The artificial turf blades showed significant levels of Ti, Fe, and Zn with only the yellow blade showing concentrations of V and Bi.

## *The Emperor's Mind in a Nutshell*

Shantilal Goradia  
Gravity Research Institute, Inc.

Theory of Everything must include consciousness as a prerequisite for it to propagate to a higher level. The assumption that complex mathematics and not a simple one like  $2E10 = 1$  kilobyte, is at the bottom of everything and stands in the way of investigation of dark matter that we imply in [1], create other invisibles. If the Emperor revolves the particle, it resembles a wave. If He decides not to do so, then it will remain a particle. We will present similar conjectures other than the ones in [2] prepared using the abstract for TSC 2016 as an introduction, and will substantiate that the information exists in the gravity waves. [1] Goradia S. 2015. "Dark Matter from Our Probabilistic Gravity", Journal of Physical Science and Application 5 (5): 373-6. [2] Goradia S. 2016. "Quantum Consciousness-The Road to Reality", Journal of Life Sciences 10:1-4.

## *Generalizations of Collatz Functions to Geometric Algebras*

Rafael Ceja Ayala<sup>1</sup>, Erik Knutsen<sup>2</sup>, Jason Turner<sup>3</sup>, and Dr. Alejandra Alvarado<sup>4</sup>

(1)California State University Sacramento, (2)Humboldt State University, (3)Union College, (4)Eastern Illinois University

Consider the map  $T$  from the positive integers to the positive integers: Let  $T(x) = 3x+1$  if  $x$  is odd and  $T(x) = x/2$  if  $x$  is even. The Collatz Conjecture, typically attributed to Lothar Collatz of the University of Hamburg, states that regardless of the initial value  $x$ , every iteration trajectory will eventually reach 1. Despite its concise statement, the conjecture has yet to be solved in over 75 years, although many have tried. In the summer of 2016, Steffen Kionke of Heinrich-Heine-Universität Düsseldorf defined generalized Collatz mappings on free abelian groups of finite rank and used geometric arguments to find cones of points with divergent trajectories. We attempt to further generalize his work to mappings on geometric algebras of finite-dimensional vector spaces, and investigate specific examples over the Gaussian and Eisenstein integers. Consider the map  $T$  from the positive integers to the positive integers: Let  $T(x) = 3x+1$  if  $x$  is odd and  $T(x) = x/2$  if  $x$  is even. The Collatz Conjecture, typically attributed to Lothar Collatz of the University of Hamburg, states that regardless of the initial value  $x$ , every iteration trajectory will eventually reach 1. Despite its concise statement, the conjecture has yet to be solved in over 75 years, although many have tried. In the summer of 2016, Steffen Kionke of Heinrich-Heine-Universität Düsseldorf defined generalized Collatz mappings on free abelian groups of finite rank and used geometric arguments to find cones of points with divergent trajectories. We attempt to further generalize his work to mappings on geometric algebras of finite-dimensional vector spaces, and investigate specific examples over the Gaussian and Eisenstein integers.

### ***Micromotors that Produce Their Own Fuel***

Daniel Broderick, SUNY University at Albany  
Dr. Joseph Wang, University of California San Diego

Micromotors present an opportunity for various applications including biomedical, mixing, and decontamination. However, these motors operate under conditions of a high acid solution and thus need to be adapted for use in neutral solutions. Here we attempt to create micromotors that produce their own fuel in a solution that is not highly acidic and move via bubble propulsion. This was done by infiltrating micromotors that were electrodeposited with peroxide particles and testing their movement in low concentration acid. We see the movement of the micromotor in peroxide and successful infiltration of particles but observe difficulty in having bubbling or propulsion occur in infiltrated motors.

### ***Visualizing Silicide Formation via Interface Electrostatics of Metal/Semiconductor Interfaces with BEEM/W.***

Nolting, C. Durcan, J. Rogers, S. Gassner, D. Pennock, J. Goldberg and V. LaBella

College of Nanoscale Science and Engineering, SUNY Polytechnic Institute

Nanoscale fluctuations in the electrostatics of a metal semiconductor interface impact performance and are important to understand, which can be accomplished with ballistic electron emission microscopy (BEEM), an STM based technique. In this work, we perform BEEM on Cr/Si Schottky contacts to visualize the interface electrostatics to nanoscale dimensions to understand the effects of silicide formation. This is accomplished by acquiring tens of thousands of spectra on a regularly spaced grid and fitting the results to determine the local Schottky barrier height. Monte-Carlo modeling is utilized to calculate the barrier height distributions that includes scattering of the electrons that traverse the metal layer and a distribution of electrostatic barriers at the interface. Improved agreement between the model and the data is achieved when specifying more than one barrier height, providing a signature of silicide formation. This, and recent work extended this method to the W/Si interface will be presented.

### ***Order or Disorder? A Kinematic Analysis of Starburst Galaxies at $z \sim 1$***

Brittany Vanderhoof, Jeyhan Kartaltep  
Rochester Institute of Technology

Luminous infrared galaxies are gas-rich, starburst galaxies that are common around redshift 2-3. Understanding the dynamics of these unique objects gives insight into the major contributing processes that shape the galaxies we observe today. Using H alpha measurements from Keck telescope, I conduct a kinematic analysis of the bulk motion of these galaxies to determine the role of mergers in the morphology and extreme luminosity of these objects.

## ***Ancestors of the Brightest Cluster Galaxies***

Kevin Cooke<sup>1</sup>, Jeyhan Kartaltepe<sup>1</sup>, Krystal Tyler<sup>1</sup>, Behnam Darvish<sup>2</sup>  
(1) Rochester Institute of Technology, (2) California Institute of Technology

The most massive galaxies in the universe are the Brightest Cluster Galaxies (BCGs), which formed through a complex series of mergers and star formation episodes not fully understood. The extreme size of their stellar populations hints toward intense star formation episodes long ago, with the further delivery of additional stars through mergers with other galaxies. To investigate when the most mass growth occurs, I identify galaxies using the constant and evolving number density method to identify progenitors of low redshift BCGs. I retrieve observations from the COSMOS Hubble Space Telescope survey to construct a SED for each ancestor candidate, which is then fit to stellar, dust, and sometimes AGN models simultaneously. By tracing the specific star formation and stellar mass of BCG ancestors in the early universe, we gain a new understanding of when the largest individual structures in the universe developed.

## ***First principles simulation of atomic displacement in two-dimensional transition metal dichalcogenides under electron irradiation***

Anthony Yoshimura and Vincent Meunier  
Rensselaer Polytechnic Institute

Electron beam irradiation by transmission electron microscopy (TEM) is a common and effective method for post-synthesis defect engineering in two-dimensional transition metal dichalcogenides (TMDs). Combining density functional theory (DFT) with relativistic scattering theory, we simulate the generation of such defects in monolayer group-VI TMDs, MoS<sub>2</sub>, WS<sub>2</sub>, MoSe<sub>2</sub>, and WSe<sub>2</sub>, focusing in particular on two fundamental TEM-induced atomic displacement processes: chalcogen sputtering and vacancy migration. Our calculations show that the activation energies of chalcogen sputtering depend primarily on the chalcogen species, and are smaller for TMDs containing Se. Meanwhile, vacancy migration activation energies hinge on the transition metal species, being smaller in TMDs containing Mo. Incorporating these energies into a relativistic, temperature-dependent cross section, we predict that, with appropriate TEM energies and temperatures, one can induce migrations in all four group-VI TMDs without simultaneously producing vacancies at a significant rate.

## ***Mapping the circumnuclear gas of NGC 4180 and MCG-06-30-015***

Trent Seelig  
Rochester Institute of Technology

The growth process of supermassive black holes (SMBH) in the centers of galaxies has been observed to influence the stellar evolution of the host galaxy by radiative and kinematic feedback mechanisms. At distances of tens of parsecs from the nucleus, how does the inwards flow of material fueling the growth process relate to the luminosity and the kinematic power of the Active Galactic Nuclei (AGN) and associated outflows? As part of a larger team studying AGN spanning a broad range of powers we are analyzing two galaxies MCG-06-30-015 and NGC 4180. Observations were performed with the GEMINI Multi Object Spectrograph Integral Field Units (GEMINI GMOS IFU) located in Hawaii and Chile. Our goal is to map the gas flows and disentangle the non circular motions from the circular rotation patterns to determine the rates of mass inflow and outflow. We search for evidence of structures that may be feeding the AGN as well as feedback resulting from the SMBH growth. IFU datasets allow us to produce maps of the motion of the gas, as well as its temperature and density, in the central region of these galaxies to determine these parameters. The results of our study will eventually be included with those of similar studies to understand the relation of galactic host properties and the properties of their AGN.

## ***Monsters on the move: Gravitational wave recoiling supermassive black hole candidates***

Yashashree Jadhav (Rochester Institute of Technology), Dr. Andrew Robinson (Rochester Institute of Technology), Dr. Davide Lena (Netherlands Institute for Space Research)

There is compelling evidence that supermassive black hole (SMBH) reside at the centers of all large galaxies and are the gravitational 'engines' of Active Galactic Nuclei (AGN). Mergers between galaxies are thought to have played a fundamental role in the growth and evolution of the largest galaxies in the nearby universe. A galaxy merger leads to the formation of an SMBH binary, which eventually coalescences through the emission of gravitational waves and receives a gravitational recoil kick (up to several 1000km/s). This recoil in turn causes the merged SMBH to oscillate (up to  $\sim 1$  Gyr) in the gravitational potential well of the galaxy. During this time, the recoiling SMBH may be observed as a 'displaced' AGN. These events are a strong test of gravitational physics and merger frequency of binary SMBH. Recoiling SMBH can be detected via electromagnetic signatures. As a result of residual oscillations, displacements  $\sim 10 - 100$ pc may be expected even in nearby elliptical galaxies and can be measured as spatial offsets of AGN in high resolution optical or infrared images. In a preliminary study, isophotal analysis was conducted on a sample of 96 galaxies to obtain the photocenter of the galaxies using mostly Hubble Space Telescope (HST) archival images (mostly in the visual filters). The position of the nuclear point source (AGN) was also measured to obtain a displacement vector. Analysis of this initial sample reveals 18 candidates that show a significant displacement. Of these, 14 are hosted by core ellipticals while the rest have a cuspy light profile. A majority of the galaxies analyzed have galactic and nuclear dust structures that interfere with the isophotal analysis. We will also present preliminary results from new HST infrared images (in filters F110W and F160W) of 2 of the 18 candidates.

## ***Resolved Stellar Populations in High Redshift Galaxies***

Meaghann Stoelting  
Rochester Institute of Technology

I aim to investigate individual stellar populations within galaxies from the COSMOS survey between  $1 < z < 3$ . Using the relationship between global and local galaxy properties, one can study galaxy evolution on a small, resolved scale for an individual galaxy. To achieve this, I am fitting spectral energy distributions (SEDs) per resolution element for a sample of galaxies in order to derive galaxy properties such as, star formation rate (SFR), stellar mass, stellar age, and dust content. From these SEDs, we can define particular regions in each galaxy that have differing local properties and compare these regions to the overall integrated galaxy properties. Defining these properties locally can tell us how galaxy structure evolves internally, which in turn, we can relate to overall the evolutionary sequence.

## ***Challenges and Joy of Teaching an Undergraduate Course in Gravitational Astronomy***

Manju Prakash,  
Hofstra University

Hundred years after the prediction by Albert Einstein, the gravitational waves were detected directly on September 14, 2015 at 5:51 a.m. Eastern Daylight Time by the twin LASER Interferometer Gravitational Wave Observatories (LIGO) detectors located in Livingston, Louisiana and Hanford, Washington. These gravitational waves are ripples in the fabric of space-time and originated when a 36 solar mass black hole merged with its binary companion of 29 solar mass black hole, nearly 1.3 billion light years away. These observations confirm the dawn of gravitational astronomy and have opened whole new frontiers for understanding exciting phenomena occurring in the cosmos, such as collision of black holes, dense matter inside neutron stars, and early universe. Electromagnetic waves that are currently used as a tool in astronomy are inadequate to shed light on these phenomena. Gravitational Astronomy holds the potential to bring a paradigm shift in how we view and understand our universe. This presentation will discuss different teaching approaches, strategies, and curriculum modules to teach Gravitational Astronomy to undergraduates students. These efforts will train a next generation of scientists and teachers who will advance the field of gravitational astronomy through education, novel experimental, and theoretical ideas.

## ***Making Lemonade out of LEMON: Improved Photometry Processing Software***

Mackenna Wood, Dr. Joshua Thomas  
Clarkson University

When studying variable stars it is often necessary to view the brightness of the star over a period of time spanning multiple observations. While there is software available for the analysis and plotting of photometric data, it is not capable of combining the data from multiple observation sets. This research aims to create a program which will work with existing software to combine multiple observational sets, do long term photometric analysis of stars, and flag potentially variable stars. By being able to easily view the photometry of stars over extended periods of time it will be easier to notice changes in brightness over long periods, or confirm changes over short periods. The additional ability of the program to remove noisy stars will allow the astronomer to narrow the number of stars which require personal attention. This will then be used as a tool to locate and analyze variable stars.

***Vibrational modes in few layer WTe<sub>2</sub> revealed by first-principles calculations***

Natalya Sheremetyeva  
Rensselaer Polytechnic Institute

***Investigating Barkhausen Noise in Relaxor Ferroelectrics***

Jennifer Freedberg, Thomas Kennedy, Xinyang Zhang, Dr. Eugene Colla, Dr. Michael Weissman  
University of Illinois at Urbana-Champaign, Rensselaer Polytechnic Institute

Barkhausen noise is a useful method to probe the behavior of ferroelectric domains around ferroelectric phase transitions. Our experiments are an attempt to understand the kinetics of relaxor ferroelectrics. Previously published results show that Barkhausen spikes can antialign with the applied electric field when a phase transition is induced in the relaxor PMN-PT12. New efforts to observe and explain reverse Barkhausen spikes in the relaxor PMN-PT20 are detailed in this poster. This effect is hypothesized to arise from some nanodomains blocking the reorientation of others, which could force those domains to align against the field. New data appear to support this hypothesis.

***A statistical model of chamber pressure for application in Monte Carlo simulations of sputter depositions***

William "Joe" Meese; Toh-Ming Lu, PhD.  
Rensselaer Polytechnic Institute

The statistical effects of different deposition conditions have on thin film morphology have long been the subject of interest. One notable effect is the qualitative column development due to differential chamber pressure in Thornton's Structure Zone Model, specifically in Zone 1. In this work, we propose an incident Gaussian flux model developed from a series of binary hard-sphere collisions and simulate its effects using conventional Monte Carlo methods with a solid-on-solid growth scheme. We also propose an approximate cosine-power distribution for faster future Monte Carlo sampling. With this model, it is observed that higher chamber pressures increase the growth of column diameters and the film wavelength. It is seen for low pressures that both the column diameter exponent and the wavelength exponent are very sensitive to changes in pressure for low pressures; meanwhile both exponents saturate for higher pressures around a value of 0.6.

***Electrical properties of carbon doped inorganic / organic heterojunctions***

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Inorganic/organic (hybrid) heterojunctions are steadily proving themselves to be viable alternatives to silicon-based junctions, and electrochemically fabricating these heterojunctions is a potentially viable

method of mitigating the adverse effects of the grain boundary. ZnS/PEDOT junctions have been demonstratively comparable to that of ZnO/PEDOT and can be produced through electrochemical means; enabling reliable upscaling for broader applications. Doping inorganic/organic heterojunctions with conductive carbon-based materials such as carbon black or graphene oxide can predictably increase the conductivity of the organic component, thereby improving the overall performance of the heterojunction. The electrochemically-doped hybrid heterojunctions are characterized through XRD, UV-Vis, potentiostatic EIS, two-probe electrical measurements for diode performance, and four-probe measurements to relay optical and electrical properties of the composite thin film. Preliminary results have suggested that doping these hybrid junctions with carbon black may significantly increase the measured conductivity values, although more research is needed.

### ***"EXONEST: The Exoplanetary Explorer"***

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The launch of the Kepler Space Telescope in 2009 has led to the discovery of more than 3500 confirmed exoplanets with about 4500 candidates. To fully take advantage of the available photometric data, new and more powerful computational tools are required. EXONEST is a software package currently under development which uses photometric effects present in the Kepler (and CoRoT) data, including the primary and secondary transit, the exoplanet's thermal emissions, reflected and refracted light, the star's ellipsoidal variations and the Doppler boosting effect to characterize the exoplanet. To estimate exoplanet parameters such as the radius, the temperature, the eccentricity of the orbit and the mass, EXONEST relies on the Metropolis-Hastings Markov chain Monte Carlo (MCMC) method and Bayesian inference techniques; e.g. the nested sampling algorithm and its variant, MultiNest, to efficiently probe the parameter space.

### ***Don't Be Blinded By the Light***

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The August 21, 2017 solar eclipse sparked an interest in science. Many people viewed the Sun with eyewear approved by NASA with the ISO 12312-2:2015 standard printed on them, while others purchased potentially unsafe eyewear, or used homemade eyewear with commonly available items. We present a relatively simple experiment that can be done in a classroom setting to demonstrate why it is unsafe to look at the Sun with non-approved eyewear. This experiment can connect students with real-world events and perhaps spark a deeper interest in STEM. Students compare spectra of the Sun taken through various eyewear to the officially approved eyewear. The students also learn about light that is not perceived by the eye, but let through the eyewear that can cause irreparable damage to the human eye.