Poster Session

2017 Conference for Undergraduate Women in Physics at the University of Wisconsin-Madison

1. **Non-Invasive Optical Diagnostics for the Plasma Couette Experiment**
M. Tabbutt, K. Flanagan, J. Milhone, M. Nornberg, F.L. Roesler, and C.B. Forest
A non-invasive optical diagnostic has been developed for the Plasma Couette Experiment Upgrade (PCX-U). PCX-U is capable of producing electron temperatures of 5 to 15 eV, densities between 10^{10} and 5×10^{11} cm^{-3}, and ion temperatures between 0.5 eV to 2 eV. The diagnostic described utilizes a low cost USB spectrometer for optical emission spectroscopy (OES). Combined with a modified coronal model, OES is used to measure electron temperature in Argon plasmas. The spectrometer is mounted on a linear stage for scanning chords across the plasma volume. Abel transform techniques are used to create radial profiles of measured plasma properties.

2. **Density Measurement of Compact Toroid with Mach-Zehnder Interferometer**
Lauren Laufman-Wollitzer , D. Endrizzi, M. Brookhart, K. Flanagan, J. Egedal, C.B. Forest, WiPAL Team, H. Gota, T. Roche
Utilizing a magnetized coaxial plasma gun (MCPG) built by Tri Alpha Energy, a dense compact toroid (CT) is created and injected at high speed into the Wisconsin Plasma Astrophysics Laboratory (WiPAL) vessel. A modified Mach-Zehnder interferometer from the Line-Tied Reconnection Experiment (LTRX) provides an absolute measurement of electron density. The interferometer is located such that the beam intersects the plasma across the diameter of the MCPG drift region before the CT enters the vessel. This placement ensures that the measurement is taken before the CT expand. Results presented will be used to further analyze characteristics of the CT.

3. **Glass/Polymer Composites With Bactericidal Properties**
Victoria Eng, Mario Affatigato, Michael Leonardo, Lin Du, Evan Lamb
Most bactericidal glasses use silver as the antibacterial agent. This project started with the goal of creating a long-lived bactericidal glass that did not contain silver. Other Coe researchers were successful using lithium-borate and lithium-potassium-borate glasses that inhibited the growth of S. aureus, E. coli, and S. typhimurium. The glass surfaces created either an acidic or basic environment, depending on the glass content, that killed the bacteria. But their hygroscopic nature made them impractical, with full dissolution times on other order of hours.
In the present study we worked to create a more durable but still effective bactericidal material. To do this we mixed crushed lithium borate glass powder into an epoxy to create a mechanically-strong composite. The composites were then tested with the same protocols as the lithium borate glasses. Our recent work has focused on optimizing the testing procedure for the composites; finding the ideal composition of

the glass component; determining which polymer works best; and perfecting the ratio of glass to polymer. Recent results proved that the pure epoxy provides no bactericidal effects once dried. Increasing the fraction of glass in the composite seems to yield stronger bactericidal action, but the effect appears muted past a mass fraction of 33%. Scanning Electron Microscopy (SEM) has also enabled the observation of the glassy regions (and their sizes) within the composites.

This work was supported by the Center for the Study of Glass at Coe College, and under grant NSF-DMR-MRI-0722682.

4. **Boosted Top Jet Tagging at 100 TeV**

   Lauren Ennesser, Robert W. Tabb, Dr. Richard Cavanaugh

   The identification of top quarks at particle colliders such as the Large Hadron Collider via the resolution of constituent subjets is accomplished by use of various algorithms that analyze the substructure of these jets. These algorithms work well at energies at and below 13 TeV, but in order to probe new physics, higher energies will have to be used. To study boosted top quark jets at these higher energies, the jet substructure algorithms must be tested to determine which ones work best for resolving the jet substructure at these higher energies. We used particle level data produced in Pythia 8.2 of W and top quark jets at 13 TeV and 100 TeV with transverse momenta of 1 and 5 TeV respectively. We tested four jet grooming methods (pruning, trimming, soft drop, and modified mass drop), and two jet substructure algorithms (n-subjettiness and the energy correlation function parameter). We compared these results with the particle level QCD background. We found that grooming methods that are successful at lower energies are less effective at 100 TeV, and the more sensitive methods also have a higher mistag rate. We also found that while the substructure algorithms are not as sensitive at higher energies, they are still able to distinguish the jet substructure from the background.

5. **Design of Millimeter-Wave Bandpass Filters for CMB Detectors**

   Elizabeth Dabrowski and Peter Timbie

   The B-Mode polarization signal of the Cosmic Microwave Background is highly obscured by foreground noise. By gaining better data from contamination we can better isolate the signal from the B-Mode polarization in the CMB. The goal of this project was to create a microstrip filter to spilt incoming frequency into multiple bands to allow higher resolution. We will design multiple microstrip filters to create frequency bands ranging from approximately 200 GHz to 400 GHz. Our filters be able to function with various ground based experiments such as CLASS, POLARBEAR, and ACT with only minimal scaling and modifications to the design and materials used.

6. **Observing Masked Quantum Noise Signals to Improve Gravitational Wave Detection**

   Aliza Beverage, Thomas Corbitt

   The hunt for gravitational waves is limited in part by quantum noise. This study was conducted to better evaluate the performance of squeezed light in reducing the effects of quantum noise. In order to observe the effects of the squeezed light, the noise floor of the tabletop experiments needs to be at the quantum limit. Due to the challenge of suppressing thermal noise at room temperature, the cross power spectrum and coherence between two signals are explored as an alternative way to observe quantum noise. This signal processing technique was first tested on signals generated in the lab and then on the tabletop with real laser light. The technique will be implemented directly following the installation of the squeezed light.

7. **Absorber Coatings for Mid-Infrared Astrophysics**
Dahlia Baker, E. J. Wollack, K. Rostem
Control over optical response is an important aspect of instrument design for astrophysical imaging. Here we consider a mid-infrared absorber coating proposed for use on HIRMES (High Resolution Mid-Infrared Spectrometer), a cryogenic spectrometer which will fly on the SOFIA (Stratospheric Observatory for Infrared Astronomy) aircraft. The aim of this effort is to develop an absorptive coating for the 20-200 microns spectral range based on a graphene loaded epoxy binder (Epotek 377H) and glass microsphere scatters (3M K1). The coatings electromagnetic response was modeled using a Matlab script and the glass microspheres were characterized by the measured size distribution, the dielectric constant, and the filling fraction. Images of the microspheres taken by a microscope were used to determine the size distribution with an ImageJ particle analysis program. Representative test samples for optical evaluation were fabricated for characterization via infrared Fourier transform spectroscopy. The optical tests will determine the material’s absorptance and reflectance. These test results will be compared to the modeled response.

8. **Snow Interference on Cosmic-Ray Showers in IceTop**
Julianne Pyron and Frank McNally
Since December 2010, the IceCube detector at the South Pole has been collecting data on cosmic-ray air showers. During that time, a considerable amount of snow has collected on the surface component of the array, IceTop. The snow affects the electromagnetic component of the air showers, skewing the data and not providing the most accurate information about the showers. By using likelihood methods with IceTop data, we can estimate the core position and primary energy of particle showers. Through simulation, we study how the reconstructed primary energy and core resolution change as a function of true energy or core position. Using these graphs, we can try to correct for the errors caused by snow on top of the detector.

9. **Diffusion Induced Δn Amplification in Holographic Photopolymers**
Madeline Chosy, David L. Glugla, Amy C. Sullivan, Marvin Alim, Robert R. McLeod
The ability to create an arbitrary index distribution within holographic photopolymers offers an attractive method for fabricating 3-D optical interconnects and holographic optical elements. Optical interconnects provide a means for faster chip-to-chip communication while holographic optical elements show promise as tools for

implementing virtual reality devices such as heads-up displays. However, for successful application, a high refractive index contrast must be achieved in these materials and index contrast must be well characterized. Most current materials are limited to index contrast values of about 0.02. My research this summer focused on characterizing index contrast over a variety of optical exposure conditions using the transport of intensity (TIE) equation. I also used repeated exposures on a sample to reach amplified index contrast values of up to 0.03.

10. **Analysis of Elevation Dips in the Balloon-Borne experiment EBEX**
Irene Moskowitz, Shaul Hanany, François Aubin, Chaoyun Bao
EBEX is a balloon-borne experiment that measures the polarization and intensity of the cosmic background radiation. The measurements are used to probe an inflationary period of the universe shortly after the big bang. EBEX uses bolometers as detectors. Bolometers convert power incident on the telescope to an electrical signal.
This project quantifies changes in bolometer response as a function of telescope elevation angle. This will be used to compare measurements to atmospheric models.
I analyzed two segments of data, concentrating on large changes in elevation. I quantified the detector response per degree elevation for each detector of one frequency band. Using known calibration values for each detector, I converted the values of response per degree to physical units, Kelvin/degree. These are compared to values for Kelvin/degree calculated from atmospheric models. For the first data segment, the detector responses form a gaussian distribution around a mean of -0.0105 Kelvin/degree, while the detector responses from the second data segment are distributed around a mean of -0.0499 Kelvin/degree. The atmospheric models give a value of -0.0125 Kelvin/degree for this frequency band. Next steps will include investigating these differences.

11. **Structural Study of Tellurite Glasses**
Brittney Hauke, E. Barney, A. Crego, G. Tarantino, M. Affatigato, S. Feller
Tellurite glasses show the potential for use in mid-infrared optical applications, but their structure has not been intensively studied. While they do not conduct light better than chalcogenides, which are currently the best glasses for infrared optics, they are much easier to produce. Alkali and alkaline earth tellurite glasses, including single component, rapidly cooled TeO2 are reported and studied here. Specifically, potassium, boron, barium and strontium tellurites were evaluated. The results include Tg measurements and Raman spectra, and the resulting structural models are also discussed.
Acknowledgement: The NSF is thanked for support under grant number DMR-1407407.

12. **Effects of Resistivity and Viscosity on Mode Rise and Fall Times in RFP Plasmas**
April Futch - Wheaton College, Wheaton, IL; D. Craig, R. Hesse - Wheaton College, Wheaton, IL; C.M. Jacobson - University of Wisconsin - Madison, Madison, Wisconsin
In the reversed field pinch (RFP), poloidal mode number m=0 fluctuations are

driven in a sawtooth cycle with unstable m=1 tearing modes. We explore how the rise and fall time of these m=0 fluctuations depends on resistivity and viscosity in visco-resistive MHD simulations using the DEBS code. Both the resistivity and viscosity affect the rise/fall time. Rise time is insensitive to the resistivity profile but depends slightly on the viscosity profile. Fall time depends on both resistivity and viscosity profiles. The variation observed in simulation results is consistent with experimental MST data for rise time, but shows some differences for fall time. These results (and others not shown) support the idea that resistivity and viscosity profiles do not control mode behavior directly, but rather affect the dynamics of the entire sawtooth cycle.

13. **Diffuse Reflectance Study of Thermochromic Materials for Sustainable Energy Coatings**
Alexis Corbitt, Dr. John Sinko, Meredith Rupp, Travis Hislop, Dr. Kannan Sivaprakasam
Traditional solar power applications largely avoid using the infrared spectrum. Nevertheless, this region makes up almost half (~45%) of the solar power spectrum and therefore represents an untapped resource. Temperature control of buildings represents a significant cost for both businesses and private consumers. We are interested in using thermochromic materials as building coatings to help moderate solar infrared absorption and thereby offset temperature control costs for buildings. Our initial effort in this study has been to characterize materials which might represent starting points for our research. We designed and 3D-printed an optical test platform to perform reflectance measurements with an ultraviolet-visible-near infrared spectrometer over a spectral range from 350-1100nm. The test platform was constructed so that the temperature can be adjusted in real time using Peltier modules. In our experiments, temperature measurements were made using thermocouple probes and an infrared remote thermometer. We examined candidate thermochromic materials including liquid crystals and fluoran-type leuco dyes, measured spectra for both materials at temperatures from 15-40°C, and integrated to obtain overall reflectance data. The total reflectance of the liquid crystal sample never exceeded 5%, whereas the reflectance of the leuco dye samples was around 15% below the transition and nearly 50% above the transition. The reflectance and reflectance transition for the liquid crystal samples were both less than for the leuco dye samples, from which it can be concluded that the leuco dye samples are better candidates for building coatings. Both of the studied materials exhibited reflectance transitions in the visible spectrum, but lacked a strong transition in the infrared spectrum.

14. Particle Tracing in the Earth's Polar Cusps
Kendra Bergstedt, Cynthia Cattell, Ilan Roth, Kris Kersten
A 3d particle tracing code has been developed to study the movement of ions in Earth's magnetosphere using a model of the Earth's magnetic field including perturbations due to the solar wind. The code was implemented by using the Bulirsch-Stoer method for integrating ODEs, and currently functions with static magnetic and electric fields. The code will be modernized and wave perturbations will be introduced so as to study how wave-particle interactions affect particle acceleration in the Earth's

polar cusps. Understanding acceleration processes associated with ion outflow from the Earth's cusps may shed light onto the mechanisms by which the solar wind is accelerated. Having data from this simulation will aid in interpreting data from the Solar Probe Plus mission, whose goal is to experimentally determine how the solar wind is accelerated to supersonic speeds.

15. **Relationships between Bias Voltage and Resistance due too Giant Magnetic Resistance in Spin Valve Devices**
Catherine Halvorson, E. Dan Dahlberg
The effect of bias voltage on the nonlocal impedance will be investigated in ferromagnetic-semiconductor samples. The geometry is defined as a spin valve with multiple ferromagnetic-semiconductor interfaces. The measurements consist of injecting spins into a semiconductor interface and measuring the spin density at a second interface. The spin valves consist of a long semiconductor, with two ferromagnetic thin films, perpendicular to the semiconductor but parallel to each other. Difference coercivities in the ferromagnetic films allow an external magnetic field, applied parallel to the ferromagnets, to control the magnetization of the ferromagnets to be either parallel or antiparallel to each other. Injecting spins from one of the ferromagnets into the semiconductor will result in a resistance across the other ferromagnetic-semiconductor interface being smaller when the ferromagnets are parallel and larger when the ferromagnets are antiparallel. What has been described thus far has been previously reported. We will investigate the resistance difference between the parallel and antiparallel states as a function of the current magnitude injected; this is a function of the bias voltage. We will study this resistance difference not only as a function of the bias voltage across the first interface but also as a function of the bias voltage across the second interface. Determining the relation of the resistance difference to the two bias voltages has been a long standing question as the resistance of both interfaces is highly nonlinear.

16. **New quasar survey with WIRO: The light curves of quasars over ~15 year timescales**
Emily Griffith, Neil Bassett, Sophie Deam, Don Dixon, Will Harvey, Daniel Lee, Bradley Lyke, Evan Haze Nunez, Ryan Parziale, Catherine Witherspoon, Adam Myers, Joseph Findlay, Henry Kobulnicky, Daniel Dale
Quasars, a type of active galactic nuclei (AGN), are known to vary in brightness on 10 day to 7 year timescales. While it has been proposed that this variability is caused by instability in the accretion disk, Poisson processes, or microlensing, the exact cause remains mysterious. Understanding the physical mechanisms that drive quasar variability will require imaging of quasars over a wide range of timescales. In particular, the observations required to constrain longer timescales can be difficult to conduct. This summer ~1000 quasars in Stripe 82 were observed in ugriz wavelength bands using WIRO, the University of Wyoming's 2.3-meter telescope. Using these images, earlier data from the Sloan Digital Sky Survey`s observations of Stripe 82, as well as various data reduction methods, the quasars' magnitude can be studied on our extended 3 day

to 15 year timescale. Here, we present the light curves of ~1000 quasars in ugriz bands as observed over the last 15 years. This work is supported by the National Science Foundation under REU grant AST 1560461.

17. **Green Bank Telescope: Understanding Future Research of Radio Astronomy**
Ashley Walker and Dr. Kim Coble
There are many celestial objects that cannot be seen through visible light. Radio astronomy helps scientists understand the universe on a broader scale. Radio astronomy can detect astronomical phenomena such as: molecules in interstellar space, intergalactic rain, and oxygen at unimaginable distances. The Green Bank Observatory has detected pulsars, galaxies, cosmic chemistry, and more. In this presentation, we will discuss the use of radio telescopes using research directed learning modules at a collaboration workshop. The Undergraduate Alfalfa Team (UAT) is a consortium of 21 undergraduate-focused institutions nationwide investigating the distribution of neutral hydrogen gas (often known as HI) in galaxies and clusters. The UAT met June 13-17, 2016 at Green Bank Observatory. Activities included observing experiences, presentations from undergraduates on Alfalfa related research, presentations from Green Bank scientists, and interactions among ALFALFA undergraduates, graduates students, and faculty. There were four "scavenger hunts" in which the students collaborated with faculty mentors to learn how to analyze radio data using the software program TOPCAT.

18. **Utilizing student expertise in informing programmatic changes in STEM**
Felicia Davenport, Nicolette Sanders, Mel Sabella, and Kristy Mardis
The CSU Learning Assistant (LA) Program and the CSU S-STEM Program rely on student expertise and leadership to be successful.
LAs are undergraduate students who partner with faculty to improve courses. This involves LAs working with faculty to brainstorm about ways to reach students in their classes, assist in the classroom to support active engagement, co-develop activities to support learning, and identify specific student resources and needs. These partnerships place LAs in roles of significant responsibility.
S-STEM scholars are also engaged in leadership efforts at both the local and national level. They form committees to engage in outreach, social media, and professional event planning. At the national level, they are involved, as members of the NSF-funded Access Network. Access is a collaboration of equity-focused programs across institutions that empower students through mutual support.
In this poster we explore the synergy between these programs and how they rely on student expertise to create programmatic change.
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19. **Structural Evolution and Diffusion Barriers in the α-Sulfur Cathode**
Claire Arneson, Dr. Ying Ma

Lithium-sulfur batteries have the potential to provide cheaper batteries with a higher theoretical energy storage than Lithium-ion batteries. During charge and discharge, complex structural changes occur within the sulfur cathode. Various lithium polysulfides are formed that may shuttle between the electrodes. In this work, first principles calculations based on the density function theory are performed to study the structural evolution of α-sulfur during discharging. First, the surface energies and lithium diffusion barriers of a few surfaces are calculated. While a clear driving force is observed for both the (001) and the (010) surfaces, a diffusion barrier exists for the (100) surface. The structural evolution is studied with ab initio molecular dynamics by adding lithium ions at a specific rate. The interface diffusion barrier of lithium from the electrolyte into the cathode is also calculated. Finally, the elementary process that leads to the formation of soluble polysulfide is also simulated.

20. **Intrinsic mirror birefringence measurements for the Any Light Particle Search (ALPS)**
Claire Baum, David Tanner, Guido Mueller, Simon Barke, Zachary Bush, Hal Hollis, Giacomo Ciani, Tomoyuki Uehara, Gustavo Perez, Mauricio Diaz-Ortiz, Paul Fulda, Ryan Goetz, Todd Kozlowski, Joe Gleason, the ALPS Collaboration
The Standard Model is the most comprehensive theory of particle physics, yet it fails to explain phenomena such as dark matter. In the Any Light Particle Search (ALPS) experiment at the Deutsches Elektronen-Synchrotron (DESY), researchers are searching for weakly interacting sub-eV particles (WISPs). WISPs are predicted by extensions of the Standard Model that may explain dark matter and support string theory. The design of ALPS also allows researchers to measure the vacuum birefringence (BF) in a magnetic field. This vacuum magnetic BF (VMB) is predicted by QED and has yet to be confirmed experimentally. ALPS researchers must know the BF of their optics and how it is affected by a magnetic field to make reliable VMB measurements. In my research, I used a heterodyne polarimeter to perform preliminary BF measurements on a mirror. For a mirror at 45º incidence, 0º incidence, and 0º incidence with an applied magnetic field, the effective path length difference between two 1064 nm laser beams was ≈26.6 nm, 4.871 ± 0.046 nm, and 16.58 ± 0.11 nm respectively.

21. **Introduction of 19F to Study Amyloid-Ligand Interactions via Solid State NMR Spectroscopy**
Alexandra Lamtyugina, Manali Ghosh, Adedolapo M. Ojoawo, Chad M. Rienstra
With the knowledge of the 3D structure of α-synuclein (α-syn) fibrils, the protein present in brain lesions which define Parkinson's disease, the locations of binding sites of various ligands to these fibrils are now of great interest. This study is aimed at developing new methods for studying such binding sites. To test a large number of experimental conditions we are employing a model protein GB1, which has a smaller size and a simpler three-dimensional structure than α-syn fibrils. The optimal conditions will then be applied to α-syn fibrils. We have found 3-bromo-1,1,1-trifluoroacetone and 2-bromo-4'-(trifluoromethyl)acetophenone to be promising candidates for the addition of 19F to a protein via site-specific cysteine mutagenesis and thioester linkages. The

advantages of introducing 19F in nuclear magnetic resonance (NMR) experiments are its high sensitivity and a 100% natural abundance of the NMR-active 19F isotope. The preliminary results of this investigation bring us closer to utilizing solid state NMR spectroscopy to determine intermolecular distances between 19F-modified α-syn and potential lead compounds.

22. **Charge-Asymmetry Dependence of Proton Elliptic Flow in 200 GeV Au+Au Collisions**
Rachel E. C. Smith (for the STAR Collaboration), Prof. Huan Z. Huang, Dr. Gang Wang
The chiral magnetic wave (CMW) is predicted to manifest a finite electric quadrupole moment in the quark-gluon plasma produced in high-energy heavy-ion collisions. This quadrupole moment generates a divergence in the azimuthal anisotropy (v2) of positively and negatively charged particles such that v2(+) < v2(-). This effect is proportional to the apparent charge asymmetry (Ach) of particles in the same rapidity window. The Ach dependence of v2 has already been observed in the cases of charged pions and kaons. We present preliminary STAR measurements of v2 for protons and anti-protons as a function of Ach from 200 GeV Au+Au collisions for different centrality classes. The results are then compared with the previously reported results of pions and kaons.

23. **Understanding the Effect of an External Magnetic Field in X-Ray Magnetic Circular Dichroism Data**
Maria Satnik
Multilayer magnets are used in many modern types of long term data storage technology. In order to improve this technology in the future, we need to better understand the physical properties of multilayer magnetic materials. Hysteresis loops tell us valuable information about the magnetic properties of a material. X-Ray Magnetic Circular Dichroism (XMCD) is an element specific experimental technique that uses polarized x-rays such as those created by the Stanford Synchrotron Radiation Lightsource at SLAC National Accelerator Laboratory to probe magnetic properties of materials. Transmission XMCD is a useful method to image hysteresis loops, but it requires a very thin sample. The multilayer magnets are often grown on silicon wafers, and the x-rays are unable to transmit through the sample, so we use Total Electron Yield XMCD to probe magnetic properties of multilayer magnets. The Total Electron Yield XMCD produces experimental results that are not well understood. In this work, we explore theoretical models to help understand the physical phenomenon behind Total Electron Yield XMCD in multilayer magnetic materials. The two main models explored in this paper are a particle model and a wave model. In the particle model, we calculate the motion of a particle in the system using numerical approximations and classical mechanics. In the wave model, we use quantum mechanics to calculate the tunneling probability of an electron in a simplified system. When expanded upon further, both of these early theoretical results will help us understand Total Electron Yield XMCD and the properties of multilayer magnetic materials.

24. **Dimensionality Effects in Spin Ice Dy2Ti2O7**

Laura Troyer, Kenneth Schlax, Dale Van Harlingen

Spin ices have similar characteristics to water ice such as anomalous entropy at low temperatures. Spin ices display quasi-particle monopole behavior. Crystals of spin ices have been tested, but it is uncertain how thin (how close to two dimensional) a spin ice may be while displaying its characteristic properties. To this end, spin ice thin films of dysprosium titanate were grown and tested for thickness, orientation, and heat capacity. The heat capacity data from approximately 40 nm thick thin films corresponded well to expected spin ice behavior, but more testing will need to be done for more conclusive answers. If thin films successfully maintain spin ice properties, thin films of spin ice will be useful in learning how to manipulate spin ice magnetic properties.

25. **Characterizing the Spin of High Altitude Ballooning Payloads**

Rachel Newman, Erick Agrimson

A magnetometer was used to look at the rotation of high altitude ballooning payloads. The magnetometer senses the magnitude of the magnetic field, and this is used to calculate a position that the magnetometer is oriented much like a compass. Many tests were performed to see how effectively the magnetometer sensor can sense a change in position and to see if it recognizes a constant rotation rate. High altitude balloon flight simulations were conducted to see get data without actually flying.

26. **SLM generated geometric shapes for studying single-photon vision**

Amy Zou, Rebecca Holmes, Michelle Victora, Ranxiao Frances Wang, Paul Kwiat

A combined physics and psychology study at University of Illinois aims to study the lower limit of human vision, measuring temporal integration time using multi-photon trials. We have observed subjects abilities to discern a photon pulse with mean photon number ~3-4 coming from the left/right direction with 0.54 +/- 0.01 accuracy. To reduce the uncertainty, we propose using a spatial light modulator (SLM) to project light on the retina in different shapes with variable sizes and contrast. Use of the SLM provides accurate control over phase and intensity of the propagating light field. Thus, we can study how signals from nearby locations are summed and what`s the spatial relationships between rod cells on the retina. This application may also improve the observer's ability to see signals from random fluctuations in background noise during a vision test.

27. **Analysis Through Diffracted Light of Fabricated Refractive Index Gratings**

Anna Robinson, Marty Baylor, Ashley Carlson, Kai Huang

Optofluidic devices are instruments that include optical features such as fluid channels. In this research we use a special photopolymer designed to simplify the fabrication of the devices to build an optofluidic spectrometer. Refractive index gratings, which are a necessary feature of optofluidic devices, are periodic variations in the index of refraction within a material. We create the gratings by interfering two 405 nm laser beams within a thin sample of photo-sensitive polymer. A 632.5 nm laser beam is then used to interact with the grating to produce a diffracted beam that can be studied. The intensity of the diffracted beam depends on the amplitude of the refractive index variation. Therefore by monitoring the diffracted beam strength of the gratings and its development over time we are able learn about the gratings and their behavior. This poster presents results from our initial studies of gratings in our photopolymer.

28. **The Process by Which Northern African Easterly Waves Propagate Through the African Easterly Jet to Become Tropical Cyclones**
Antoinette Serrato, Dr. Tsing Chang Chen, Joshua Alland
A case study was done tracking Hurricane Karl`a propagation through the African Easterly Jet as a northern African Easterly wave. Five other northern African Easterly Wave based hurricanes are going to be looked at to determine whether or not their paths are similar to those of Karl`s to see if there is a physical process that applies to many northern African Easterly Waves in the Atlantic basin. Their latitudes and longitudes were plotted and graphed, and the detailed process of deepening and thickening will be looked into.

29. Calibration System for X-Ray Detectors
Mackenzie Meyer, Dan McCammon, Felix Jaeckel, Rachel Gruenke
A new calibration system has been built for new x-ray detectors, called Transition Edge Sensors. These detectors are superconducting films. During their transition, the resistance changes quickly with temperature. An x-ray is absorbed by the detectors, raising the temperature. By measuring the change in resistance, the energy of the x-ray can be determined.
The calibration system for the detectors uses a 405 nanometer laser diode to create a pulse of light of 100 photons. The energy of this pulse is 300 eV, which is in the soft x-ray range. Since the energy of the pulse is known, it can be used to calibrate the detectors.

30. **Electronic Band Engineering of Two-Dimensional Cu-*InSe: A First Principles Approach***
Dave Levsky, Hansika Sirikumara, Thushari Jayasekera
Since the discovery of graphene, two-dimensional (2D) layered materials have opened up new opportunities for device community. Due to the rise in popularity of 2D materials, research is being conducted on InSe to find ways to engineer its electronic properties to enhance its photo response. Recent experiments suggest that both chemical doping and functionalizing show an increase the photo response of layered InSe. This research also suggests that functionalization produces more desirable results by keeping the original structure intact. Calculations were run for Cu-functionalized and Cu-doped InSe using a 2x2 InSe supercell for the base. Both cases displayed a mid-gap state that reduced the band gap. This was caused by the impurity atoms in the Cu-doped or Cu-functionalized InSe. However, origins of the mid-gap state for the Cu-

functionalized InSe have not been determined based on the current results. It is expected that both cases show an enhanced photo response, regardless.

31. **Evaluating the effectiveness of task-based fMRI testing for patients with epilepsy on the basis of difficulty and preparedness**
Janerra Allen, Elizabeth Felton, Veena Nair, Vivek Prabhakaran
Introduction: Epilepsy is a series of seizures caused by excessive and abnormal nerve cell activity in the brain. Some causes of epilepsy include brain injury, stroke, brain tumors, brain infections, birth defects and genetic causes [1]. According to the Centers for Disease Control and Prevention, about 2.9 million people in the United States have active epilepsy. The most common form of this disorder is temporal lobe epilepsy Temporal lobe epilepsy is characterized as recurrent, unprovoked epileptic seizures that originate in the temporal lobe of the brain [2]. The temporal lobe is responsible for memory, language, intellectual and emotional functions [3]. Temporal lobe epilepsy (TLE) is the focus of this study.
Methods: We studied 20 healthy controls and 10 TLE patients who underwent noninvasive brain imaging methods such functional MRI (fMRI). fMRI is helpful in understanding how communication between brain areas change as a result of epilepsy and seizures by studying and assessing some of the major domains of the neural system. These systems include: visual and motor systems; working memory/cognitive control systems; language processing (semantic); social cognition; and emotion processing [4]. The subjects (both epilepsy patients and healthy controls) that are recruited for the study are between the ages of 18-60 and have IQ levels above 70.
Conclusions: Based on these performance results, it was concluded that patients experienced some difficulty during testing which could have been attributed to the loud scanner noise which made it hard listening to the tasks, difficulty understanding instructions or retaining, and/or feeling tired/fatigue or discomfort due to long testing procedures. Moving forward, it is recommended for future procedure to repeat tasks and instructions if necessary, explain instructions in a simpler fashion, and/or shorten testing sessions to lower tiredness and fatigue.

32. **Evolution of a Pre-Planetary Nebula Traced by an OH Maser**
A. Strack, E. D. Araya
CRL618, also known as the Westbrook Nebula, is a prototypical example of a pre-planetary nebula, i.e., an object in transition between the supergiant phase and a planetary nebula. Hydroxyl (OH) masers in pre-planetary nebulae are very rare, especially in carbon rich late-type stellar objects like CRL618, which are characterized by carbon rich instead of oxygen rich environments. Until 2008, there had been no detections of masers from oxygen-species, including OH, in CRL618. Observations in May 2008 with the 305m Arecibo Telescope resulted in detection of a 4765 MHz OH maser from CLR618. The detection was confirmed in October 2008, and it is the first detection of 4765 MHz OH in pre-planetary nebulae. Follow up observations were conducted in 2015 to investigate variability and to detect and/or set flux density limits of all other OH transitions observable with the Arecibo Telescope between 1 and 9 GHz.

No OH transition was detected in our 2015 observations, including the 4765 MHz OH line, which indicates significant variability in time scales of several years. The 4765 MHz OH line had a relative velocity of -40 km/s with respect to the systemic velocity of CRL 618, which suggests that the maser was tracing outflow material. Given the rare nature of these OH masers in pre-planetary nebulae, the relative velocity of the OH line and its variability in CRL618, our work indicates that OH masers trace a short-lived period of evolution during the expansion of late-type stars into planetary nebulae.

33. **Controlling Semiclassical Chaos in the Duffing Oscillator**
Sacha Greenfield (Carleton College), Alexei Stepanenko, Jessica Eastman, Andre Carvalho (Australian National University, Canberra); Bibek Babu Pokharel, Arjendu Pattanayak (Carleton College)

Chaotic systems contain infinitely many unstable periodic trajectories that only appear for very particular initial conditions. Given a system starting at arbitrary initial conditions, we can “control” the system onto one of these trajectories by small, properly timed perturbations in system parameters. While previously only classical chaotic systems have been controlled, we aim to control chaos in a regime where the system is also quantum mechanical. We have controlled chaos in computer simulations of the classical and semiclassical damped driven double-well Duffing oscillators, and are currently implementing control in noisy semiclassical and stochastic Schrodinger equation trajectories of the same system.

34. **Surface Composition and Morphology of Coated and Uncoated Langasite Crystals Exposed to High Temperatures**
Annelise Roti Roti and Dr. Robert J. Lad

Materials for piezoelectric sensors used in high temperature (500°C - 1200°C) applications must retain their crystallographic structure and stoichiometric composition under high thermal stress in oxidizing and reducing gaseous environments. In this work, ultra-thin films (15nm) of zirconium diboride (ZrB_2), aluminum oxide (Al_2O_3), platinum silicide (Pt_3Si), and boron nitride (h-BN) were grown on separate langasite ($La_3Ga_5SiO_{14}$) substrates. Samples of coated and uncoated langasite were subjected to annealing treatments and changes in surface morphology and chemical composition were characterized using X-ray photoelectron spectroscopy (XPS), optical imaging, energy dispersive spectroscopy (EDS), and scanning electron microscopy (SEM).

Optical imaging showed morphological defects on the surface of some samples at the micron scale, and higher resolution imaging with SEM on a subset of the bare langasite samples annealed in air revealed the existence of secondary phase particles, nanocracks, and planar grains. Despite XPS results showing negligible changes in average composition of langasite constituent species measured over large areas, it was found by EDS that morphological defects were indicative of composition inhomogeneity on the nanoscale. With this knowledge, a method for testing langasite wafer quality was devised with the aim of improving yield of device fabrication processes while growth and polishing methods for langasite are perfected by the crystal growing industry.

Keywords—langasite; high temperature; annealing; x-ray photoelectron spectroscopy

35. **Produced X-rays: Data processing and analysis**
Margaret Johnston and Christopher Fasano
Extensive photon data during storms and clear days have been collected and is currently being processed. We hope to determine an explanation for how lightning strikes produce x-rays and link these events with meteorological phenomena.

36. **Studying carbonaceous meteoritic fragments found in Antarctica by micro-Raman spectroscopy**
Jin-Sun Kim and Analía G. Dall'Asén
Meteorites provide precious clues about the formation of planets in the solar system. In particular, carbonaceous chondritic meteorites, considered the most primitive surviving materials from the early Solar System, can contribute to understand how planetisimals (the precursors to planets, of 1-100 km in radius) formed from dust (micron-size grains). These relics are mainly composed of chondrules (micro/millimeter-sized inclusions) surrounded by a matrix of microparticles. Here we present a comparative study of the structure and composition of the chondrules and surrounding matrix of different carbonaceous chondritic meteorites found in Antarctica using low- and high-resolution micro-Raman spectroscopy. We examine how these properties vary in different regions of the chondrules and matrix, capturing details from micrometer to millimeter scales. We compare the structure and composition of those samples, looking for signatures of the physical processes that drove their formation.

37. **Automatic Laser Alignment System**
Sydney Lybert, Mark Saffman, Matthew Ebert, Andrew Micklich
Lasers in optical laboratories often fall out of alignment, and have to be realigned by hand. We designed and built a system using two picomotors, an encoder, and camera, to maintain alignment of lasers used for trapping atoms.

38. **The Simulation of Flux Flow in Quasicrystals**
Ashley Heida, Dr. Yen Lee Loh
This research project studies an unusual group of materials with two exciting properties: superconductivity and quasicrystallinity. Superconductivity in crystalline materials has been extensively studied and is fairly well understood. However, relatively little research has been conducted to further understand the superconductivity in quasicrystalline materials.

The interest in the field is growing rapidly because of the potential ground breaking applications that a superconducting quasicrystal can have. Quasicrystals can be produced commercially or even found in nature, so the idea of a quasicrystal superconductor is not as contrived as one might think. If the project shows that it is indeed possible to enhance flux pinning using a quasiperiodic background potential, this technology could then be implemented to enhance superconducting wires and magnets.

The research will model the quasiperiodic superconducting Josephson junction arrays, represented by time-dependent XY models and Ginzburg-Landau models, using Visual Python and later using C++. It will investigate phase and vortex dynamics under the influence of steady or time- varying magnetic or electric fields or injected currents. The motion of the vortices and antivortices will be tracked and inspected for localized, diffusive or ballistic behavior. The possibility of manipulating vortices using electric and magnetic fields will also be inspected as the physical quantities of interest will be measured, such as the change and vortex currents and conductivities.

39. **Temperature Gradient in a Tall Diffusion Cloud Chamber**
Alexander Layton and Scott Crittenden

Alexander Langsdorf`s diffusion cloud chamber has been instrumental in studying both cloud condensation and cosmic rays, but the typical design, which is short and wide, is too cumbersome for quantitative physical measurements. In this research we attempt to develop a cloud chamber that enables precise measurements of thermodynamic properties, and also uses less dry ice to operate. The first milestone in this development is to establish that a tall, narrow chamber will retain the same temperature gradient as the classical design. We find that our homemade chamber does indeed match the classical case, allowing us to proceed with development.

40. Mounting and Transmission Measurements of XQC Filters
Rachel Gruenke, Dan McCammon, Dallas Wulf

X-ray Quantum Calorimeter (XQC) is the rocket payload that includes silicon thermistor detectors used to detect astrophysical soft x-rays. To analyze soft x-rays of a particular energy spectrum, six filters sit between the gate valve and the detector. To analyze the astrophysical data, it is useful to understand the transmission of these filters. In order to find these transmissions, XQC runs in lab with the filters in and out of alignment. The configuration to run this experiment requires mounted filters that can move in and out of line with the detector. This mount must also be vacuum sealed, as XQC runs under vacuum. My project started with optimizing a filter wheel mount so that one could determine filter positions while closed under vacuum. This was done by mounting photodiodes and small metal posts, which sent an electrical signal to a self-designed light readout box when the wheels were in position. Once completed, XQC was run to find filter transmissions. This led to a conclusion of thickness and transmission measurements for each of the 6 filters.

41. **Self-Navigation Robot Using 360 Sensor Array**
Marissa Zaleski, Nicolas Tremain, Alexander Kukay, Dylan Easterla, Jason Grubish

The goal of this project was to develop a robot that can navigate through an environment with many obstacles using a sensor array that provides a 360 degree view of its surroundings. The sensor array consists of infrared and ultrasonic distance sensors.

Four sensor arrays are swept in an angular pattern to provide a complete view of the robots surroundings. Each type of distance sensor has its own unique attributes. The data from the two sensors must be combined using a mathematical calibration algorithm to take advantage of each sensor's specific characteristics. The unique aspects of this project are the navigation program and the sensor calibration algorithm.

42. **Calculating Accessible Regions of the Parameter Space in Cosmic String Stochastic Gravitational Wave Background Models**
Margot Fitz Axen
Cosmic Strings are topological defects that can form during early universe phase transitions. In the process of evolving towards a stable string network, kinks and cusps on cosmic string loops can produce gravitational waves. Summing the contributions of all cosmic string loops in the string network leads to an incoherent, stochastic gravitational wave background. By using several proposed cosmic string models to calculate the stochastic background for a range of cosmic string parameter values, we are able to determine the regions of the parameter space in these models that will be accessible to future observations by the LIGO and Virgo gravitational wave detectors. We also use the latest Big Bang Nucleosynthesis (BBN), Cosmic Microwave Background (CMB) and Pulsar Timing Array data to provide constraints on this parameter space.