Wesleyan CUWiP Poster Abstracts

The abstracts for all of the posters have been provided for your reference. They have been topically group where possible. There is no particular order to the presentation of the abstracts.

ASTRONOMY

Investigation of Firewalls Inside the Event Horizon of Black Holes

Kallan Berglund - Brown University

I am conducting a literature review and mathematical investigation of the controversy surrounding firewalls inside the event horizon of black holes. Firewalls are a controversial attempt to solve the information paradox by suggesting a wall of heat existing inside the event horizon, providing energy to disentangle infalling particles. I am calculating what an observer would experience falling into a specifically constructed black hole, in order to determine whether the firewall constructed there is physically possible. This work is expected to invalidate a recently proposed method for constructing firewalls, while contributing to a larger body of evidence against the existence of firewalls in general.

Investigating saturated versus unsaturated driving of stellar modes by gravitational waves

Susan Blackburn - City University of New York Borough of Manhattan Community College

Gravitational waves (GWs) emitted by massive black hole binaries (MBHBs) can be absorbed by nearby stars. As a consequence of resonance between the GW frequency and quadrupolar modes in stars, observable changes in luminosity are expected as the star absorbs and subsequently discharges energy. While it has previously been shown that GWs can do work on nearby compact stars, resonant heating of normal stars has not yet been fully explored. By modeling such stars as driven, damped harmonic oscillators, we examine which stars and stellar oscillations can become saturated (versus unsaturated) for physically plausible binary-oscillator pairings. Using such models, we can compute total energy deposited in any given toy model star. Energy deposition can then be used to compute the luminosity and structural changes expected in realistic stars.

Simulations of Detectability of Extrasolar Planets by a Joint Doppler and WFIRST-AFTA Coronagraph Survey

Ashley Chontos - State University of New York at Albany

A long-term goal for the astronomical community is to image and characterize an Earth-like planet. The WFIRST-AFTA space mission will make advancements towards this goal. WFIRST will include a coronagraphic instrument to discover and characterize new exoplanets and to better characterize already known exoplanets. We present results of simulations using a Doppler survey to find lower mass planets as possible targets for WFIRST. For simulations, simplified completeness estimates (Howard & Fulton 2014) are used to test the sensitivity of a prospective Doppler campaign. We use data from the HARPS spectrograph to determine exposure times needed to achieve 1 m/s uncertainty. Stellar jitter was randomly sampled from a uniform distribution based on spectral type, treating OBA-type, FGK-type, and M-type stars separately. For survey parameters, we use campaign parameters from the WIYN telescope, assuming 10 hours per night at 100 nights per year over 6 years. In any one simulation, we find roughly 45-50 new planets that are potentially observable by WFIRST. By limiting our targets to FGKM type stars within 10 parsecs, we expect one of those planets to be less than 10 Earth masses.

Observation of the 2015 Occultation of Pluto

Rebecca Durst - Williams College

As part of a joint MIT-Williams research team, our group traveled to Mt. John University Observatory on New Zealand`s South Island to observe a stellar occultation by Pluto. Post-event analysis showed that we were around 55 km from the center line of the event. The occulted star had a magnitude in the red of 11.9 in a standard catalogue and a measured magnitude of 12.22, approximately 250 times fainter than the faintest star ever visible to the unaided eye (measured with the 61-inch US Naval Observatory telescope in Flagstaff, Arizona). According to the Royal Astronomical Society of New Zealand in 2014, Pluto`s magnitude is measure at R=14.3, making it approximately 10 times fainter than the occulted star. The brightness of the star and this difference in magnitude was so significant that we were able to operate our CCD camera at 10 Hz, meaning 10 images per second, giving us an exposure time of 0.1 seconds per image. This is the fastest speed at which we have run these cameras during an occultation.

Galaxy Masses, Star Formation Rates and Inclination
Betsy Hernandez - City University of New York Hunter College
We examine the inclination dependence of inferred star formation rates and galaxy mass estimates in the Sloan Digital Sky Survey by combining the disk/bulge de-convolved catalog of Simard et al 2011 with stellar mass estimates catalog of Mendel et al 2014 and star formation rates measured from spectra by Brinchmann et al 2004.We know that optical star formation indicators are reddened by dust, but calculated star formation rates and stellar mass estimates should account for this. However, we find that face-on galaxies have a higher calculated average star formation rates than edge-on galaxies. We also find edge-on galaxies have, on average, slightly smaller but similar estimated masses to face-on galaxies, suggesting that there are issues with the applied dust corrections for both models.

Dark Energy: Anatomy of a Paradigm Shift in Cosmology
Hannah *Hocutt - Central Connecticut State University*
Science is defined by its ability to shift its paradigm on the basis of observation and data. Throughout history, the world-views of the scientific community have been drastically changed to fit that which was scientifically determined to be fact. One of the latest paradigm shifts happened over the shape and fate of the universe. This research details the progression from the early paradigm of a decelerating expanding universe to the discovery of dark energy and the movement to the current paradigm of a universe that is not only expanding but is also accelerating.

Variable Stars in the Galactic Bulge
Julissa Sarmiento - Wellesley College
During this summer, we worked on images of the Galactic Bulge. We used image subtraction to attempt to find variable stars that corresponded to Chandra x-ray sources. We then used photometry to measure light curves of the sources to obtain more information about them, such as the period of the variability. We also referenced past data/analysis of the sources. We can then use this information, coupled with spectroscopy, to determine what kind of system made the x-rays.

A Million Years Young: Determining the Age of 11 Young Brown Dwarfs
Ellianna Schwab - Macaulay Honors at the City College of New York
Victoria Ditomasso - Macaulay Honors College at Hunter College

Brown dwarfs are substellar objects that form like stars, but that are not massive enough to fuse hydrogen and subsequently obtain star status. Brown dwarfs continuously cool and fade with time, so knowing an object's age is necessary in order to estimate its mass. One of the most reliable ways to constrain the age is to identify objects as members of coeval moving groups with reliable ages based on higher mass members. Confirming membership requires knowledge of an object's parallax distance, proper motion, and radial velocity (RV), which requires a high-resolution spectrum. Using observational data collected in 2014 from the NIRSPEC instrument at the Keck II telescope in Hawaii, we reduced high-resolution J-band spectra from 11 potentially young, nearby M and L dwarfs. We measured radial velocities and then combined these RV values with previously calculated parallax distances and proper motions to determine the likelihood of young moving group membership using the LACeWING code (Riedel et al. 2015). We confirmed memberships in the Argus Association (~40 Myr) and Tucana-Horologium (~30 Myr) with a probability of 99.5% and 66.7% respectively for two of the 11 brown dwarfs. Another one of the dwarfs had a >79.5% probability of membership in both the AB Doradus (110 Myr) and Hercules-Lyra (257 Myr) groups, which will require further inquiry to resolve. We also compared spectra of our 11 brown dwarfs to spectra of established young and field brown dwarfs in order to further understand spectral indicators of youth at high spectral resolution.

Probing Dark Matter by Modeling Gravitational Lensing of Spiral Galaxies
Samantha Scibelli - Stony Brook University

In order to understand dark matter, we must first understand gravity. Even if we can't see dark matter we are able to detect its presence due to its interaction with gravity. Gravitational lenses act as cosmic probes that let us explore this mysterious dark matter, they bend light from distant massive object creating multiple, resolvable images of a more distant source. Some of the first evidence for dark matter came about from the measurements of rotation curves, which showed that galaxies were rotating too fast when accounting for just visible matter. Even with rotation curve measurements we still cannot distinguish between the amount and distribution of dark matter in galaxies since we can assume different assumptions about the galaxy profile and still fit our predictions to the same data. We looked specifically at data from four late-type spiral galaxies with relativity high rotation velocities and modeled their rotation curve profiles using three different types of models, NFW, Burkert, and Isothermal Sphere profiles. We went a step further by converting our rotation curve parameters obtained from our modeled fits to gravitational lensing parameters that we could later use to put further constraints on dark matter halo profiles. Overall, we hope to use our results to see if degeneracies in the models can be broken, progressing our understanding of dark matter.

Exploring Distant Black Holes with the Hubble Space Telescope

Keziah Sheldon - Drexel University

Quasars are galaxies that are actively accreting material into acentral supermassive black hole. Some of the quasar's characteristics include a very bright central region, as well as being highly redshifted. Understanding the dynamics and properties of quasars can give us further information about the early universe. We can collect the light from quasars both from ground- and space-based spectrographs, on instruments such as the Hubble Space Telescope (HST)and the Sloan Digital Sky Survey (SDSS). The SDSS, which is groundbased, can collect a spectral wavelength range of 3600-10000 Angstroms (360-1000 nanometers), whereas the HST, which is a space telescope, can detect light as wavelengths as short at 1150 Angstroms. Combining the two allows us to see emission from a wide range of elemental isotopes, e.g. CIV, MgII, and Hbeta. Without this ability, we would have to piece together the full "spectrum from different objects at different distances/redshifts. By searching the HST Mikulski Archive for Space Telescopes (MAST) and the SDSS master quasar catalog we will be able to estimate the masses of the black holes that power each quasar using multiple lines which will help us determine which measurements are the most robust. This process should significantly improve our estimates of the black hole masses for the most distant quasars in the Universe."

Infrared SED Decomposition of Active Galactic Nuclei

Emily Stump - Williams College

We developed a code, clumpyDREAM, to decompose the spectral energy distributions (SEDs) of 83 active galactic nuclei (AGNs). We used the parameters obtained from this decomposition to compare the characteristics of the obscuring medium (dusty tori) surrounding black hole accretion disks of Type 1 and Type 2 Seyfert galaxies. In the simplest version of AGN unifying schemes, the only parameter that should distinguish Type 1 and Type 2 AGNs is the torus inclination. We find, however, that Type 2 galaxies from this sample have overall larger tori, both in angular scale height and radial extent, suggesting a possible intrinsic difference in the structures of Type 1 and Type 2 AGNs.

The Effect of Atmospheric Hydrogen on the Albedo and Surface Temperature of Mars

Nicole Wallack - State University of New York at Albany

The presence of hydrogen in planetary atmospheres has been shown to have the potential to dramatically effect the temperatures of planets. The collision-induced absorption (CIA) of hydrogen with carbon dioxide or nitrogen has been shown to have a substantial effect on the atmospheric temperature and albedo of a planet, possibly to the point at which life could exist on a planet where without such CIA the planet would be too cold. Using a single-column radiative-convective climate model, we investigated the effect of the presence of hydrogen on planetary temperatures and albedos across different amounts of hydrogen and across host stars of different temperatures using present-day Mars-like planets. We found that the addition of hydrogen in a planet`s atmosphere increased the surface temperature of the planet. This effect was stronger for the planets orbiting hotter stars. The water vapor profiles showed that this was the case due to the presence of more water vapor in the atmospheres of planets orbiting hotter stars across all percentages of hydrogen. The water vapor concentrations also varied more with the addition of more hydrogen for the planets orbiting hotter stars.

Zonal Wind Variability of Jupiter, Neptune, and Uranus

Kathryn Waychoff - Dartmouth College

I plot the zonal wind velocities of Jupiter, Neptune, and Uranus, given observational images and data of the three planets. Clouds and other atmospheric structures at a variety of wavelengths can be compared from one full rotation to the next. The change in location and shape of these structures is caused by winds at different latitudes. A plot of the wind velocities given at each latitude creates a zonal wind profile for a given rotation of the planet. Comparisons of these profiles over time show how the atmosphere of a planet changes on a longer time scale. Zonal wind profiles for Jupiter have already been made using Hubble data from the 1990s to today as well as Cassini and Voyager data at a variety of given wavelengths. Different wavelengths show the cloud structures at different depths of the overall atmosphere, which leads to a more accurate zonal wind plot. Improvements to the profile can be made by enhancing contrast in the Hubble images. Neptune and Uranus, with significantly fewer obvious features, pose more of a challenge. Data from Hubble in September of 2015 are the primary sources for Neptune's wind profiles, and they need to be enhanced significantly. As the Hubble images for Uranus show almost no features, the techniques for analyzing the data are more complicated. The goal of this project is to create current zonal wind profiles for Jupiter, Neptune, and Uranus, and show how those profiles develop over an extended time period.

HIGH ENERGY AND PARTICLE PHYSICS

Measuring the Neutral Kaon Branching Ratio in the K0TO Experiment

Carolyn Gee - Bryn Mawr College

This experiment studies Charge-Parity (CP) asymmetry by investigating a rare decay mode of the neutral kaon, K_0-->Ï€Î½Î½, at the Japan Proton Accelerator Research Complex (J-PARC) in Tokai, Japan. This K_0 decay is especially of interest as one of the 4 "golden decays in particle physics. Current models do not completely explain the amount of CP asymmetry experimentally observed. One consequence of CP asymmetry is the domination of matter over anti-matter in the universe. Based on the Standard Model (SM) which means one out of 50 billion K_0`s is expected to decay this way. New physics such as an explanation for CP violation or the existence of a non-SM particle.

CRIBFLEX

Sarah Coccia - Drexel University

CRIBFLEX is a novel approach to mid-altitude observational particle physics intended to correlate the phenomena of semiconductor bit-flipping with cosmic ray activity. Here a weather balloon carries a Geiger counter and RAM memory to various altitudes; the data collected will contribute to the development of memory device protection.

Seasonal Variation of Atmospheric Neutrinos in IceCube

Eesha Das Gupta - Drexel University

Located at the South Pole, the IceCube experiment indirectly detects neutrinos, weakly interacting elementary particles. IceCube consists of a cubic kilometer of ice with over 5000 light sensors. High energy cosmic rays, which are atomic nuclei of extraterrestrial origins, continuously bombard Earth's atmosphere to produce pions and kaons. The decays of these atmospheric interactions yield both neutrinos and muons whose interactions with the Antarctic ice allow for observation. Variation in atmospheric density leads to variation in interactions of pions and kaons with the atmosphere. Atmospheric density varies with temperature, which in turn, varies seasonally. Using two years of IceCube data, I did a computational and statistical analysis of event rates for atmospheric neutrinos in the Northern Sky. I performed this analysis for six regions with varying latitude ranges since temperature varies with latitudes. A distinct pattern, showing an increase in neutrino flux during summertime and a decrease in wintertime was observed. This indicates a seasonal dependence of northern atmospheric neutrino flux. Ratio of production of pions to kaons is impacted by temperature. My research, if continued, can lead to determination of this ratio. When these results were compared with results of a similar analysis with muons, we observed opposite trends as expected, since the South and North have opposite seasons.

The Hunt for the Z` Boson: Re-weighting ATLAS Monte Carlo Simulations

Genya Crossman - University of Massachusetts Amherst

This study explores data of dimuon mass distribution currently ignored by the Standard Model Drell-Yan (SMDY) weighting in pursuit of predicting the Z? Boson. By changing the abstract Î¸_(E_6)angle to eight different values other than the BSM value of 0.00 rad, eight new weighting models are tested on ATLAS Monte Carlo simulation data. Before continuing with quantitative analysis, the new methods are checked for relative accuracy by superimposing the histograms of each of the new models onto the traditional SMDY weighting. This qualitative analysis produces clear histograms that, in general, show the eight new methods have decreasing numbers at increasing dimuon mass distributions. However, unlike the SMDY weighting, there are clear resonance peaks at higher masses. This suggests that a further analysis in the form of a Ï‡2 test should be done for the new models.

CONDENSED MATTER PHYSICS AND BIOPHYSICS

Growth of Two-dimensional Hexagonal Boron Nitride (h-BN) on Copper Foil

Gayle Geschwind - Stony Brook University

Hexagonal-Boron Nitride (h-BN) is used as both a dielectric and lubricant. Two-dimensional (2D) h-BN crystals are used as a substrate on which to grow other 2D materials, such as graphene and transition metal dichalcogenides (TMDs) for device applications. h-BN is also extremely effective as a lubricant, and shows high mechanical strength and very good chemical inertness. A reliable, reproducible method of growing single and few layer h-BN has yet been elusive. In this study, 2D h-BN triangles and films are synthesized using low-pressure chemical vapor deposition (LPCVD). With this method, we were able to hone in on the ideal conditions for the growth of 2D h-BN. h-BN samples were examined with SEM with promising results. Our method shows a controlled growth of 2D h-BN crystals, by which samples with full coverage and/or with areas of triangles can be grown. Different transfer processes for transferring 2D crystals to TEM grids have also been attempted.

3D flow visualization of the wake of a flexible cylinder undergoing vortex-induced vibrations using digital particle image velocimetry

Emma Thomas - University of Massachusetts Amherst

Vortex-Induced Vibrations (VIV) have been studied for years due to problems they pose for marine structures that make use of long, cylindrical cables such as oil rigs and off shore wind energy systems. Due to the high cost and difficult implementation of obtaining 3D datasets, the wake of a cylinder undergoing VIV has typically been visualized using separate 2D slices oriented perpendicular to the vibrating cylinder. This method is limited to detecting vorticity within the sampled plane and only provides data representing a single location along its length. In order to create a 3D reconstruction of such a cylinder’s wake, we used Stereoscopic Digital Particle Image Velocimetry to obtain 2D vorticity fields of the flow at several different locations. Since the slices were recorded at different times, motion tracking of the cylinder was used to find the periodicity of the vibrations, allowing both the cylinder’s motion and the shape of the water flow to be averaged across many cycles (or phase-averaged). Slices of the wake are recorded at 20 locations, spaced 1 cm apart along a cylinder with a diameter of 0.635 cm. Currently, a phase-averaged wake representing a typical cycle has been assembled using the z-component of vorticity, as in previous 2D experiments. The methods developed here, however, may be used to find vortices in other directions, and will ultimately allow for more accurate analysis of a range of similar experiments aimed at characterizing the shape of the wake of a flexible cylinder undergoing VIV.

Biocatalytic Induction of Supramolecular Organization in Light Harvesting Porphyrins

Cindy Gomez - Hofstra University

Our dependence on fossil fuels has lead to many environmental problems and a demand for clean energy. Solar energy and photovoltaic systems are very promising but have encountered limitations. Nature produces clean energy by the process of photosynthesis, converting solar energy into chemical energy. There have been efforts made to mimic photosynthesis for the production of clean fuels via solar energy. Peptide self-assembly has become a popular area of research due to its chemical and structural diversity along with the possibility of successfully finding a link with biological systems. Peptide self-assembly is a process in which peptides have the ability to undergo spontaneous assembling into ordered structures. The nano-scale structures arise from intermolecular non-covalent interactions such as electrostatic, hydrogen bonding, Ï€ stacking, van der Waals and hydrophobic interactions. This process is an essential process of life and has inspired bottom-up self-assembly. A variety of nanostructures have been synthesized over the past decade, such as nanotubes, nanofibers, and nanorods. We have investigated known self-assembling systems and the effects on chemical composition and nanostructure when porphyrin, a main component of light-harvesting molecules found in chlorophyll, is added to the system. Molecular self-assembly can be controlled by a variety of factors such as solvent polarity, ionic strength and other stimuli. We investigated thermodynamically controlled self-assembly, driven by enzymatic condensation of amino acid derivatives. We examined Fmoc-dipeptide-methyl esters that are known to form hydrogels, such as KY, SL and TL. The systems form aromatic peptide amphiphile gelators. The peptide sequence is very specific to the morphological and mechanical properties of the system. We incorporate different porphyrins to the system and compare the changes in properties. We wish to understand how the porphyrins react with the system.

Designing novel anti-inflammatory drugs by targeting the CD domain of the MAP kinase p38Î±

Kalina Slavkova - University of Pennsylvania

The activation of the kinase p38Î± initiates production of proinflammatory cytokines in the human innate immune response. Toxoplasma gondii, the parasite responsible for toxoplasmosis, targets this pathway by secreting a protein, GRA24, that binds the common docking (CD) domain of p38Î±, inducing autophosphorylation and thus implementing host immunity to regulate parasite population. This study reports on the structure and kinetics of the p38Î±-GRA24 complex and the purification of the natural activator of p38Î±, MEK6. In order to determine which regions of GRA24 interact with p38Î±, the complex was digested by four proteases followed by SDS-PAGE and mass spectrometry analysis. No predicted GRA24 fragments were found, suggesting that cutting-sites are inaccessible due to extended interaction beyond the known binding motifs. Further structural studies using X-ray crystallography were conducted using crystals of p38Î± and p38Î± bound to a synthetic peptide derived from GRA24 (GRA24IRD) hypothesized to be the shortest required sequence for binding and activation of p38Î±. Diffraction has been observed; though, more data is being gathered for conclusive results. Kinetics of the p38Î±-GRA24IRD complex were calculated with three trials of isothermal titration calorimetry. This yielded an average dissociation constant of 6.7 Î¼M, indicating strong affinity and many polar interactions. A radioactive assay confirmed induced autophosphorylation of p38Î±. Due to its high affinity for the p38Î± CD domain, the GRA24 binding motif was used to replace the analogous domain in MEK6 to stabilize the naturally transient interaction between MEK6 and p38Î± for purification and crystallization purposes, which are under way.

Three-Dimensional Microfabrication of Cell-Membrane for a Three-Dimensional Microfluidic Cell Array

Mahin Tariq - Hofstra University

3D Microfluidic device fabrication requires sophisticated technology and facilities. The use of new 3D nano/micro printing technologies is emerging as an alternative for rapid prototyping of microfluidic devices. Here, a new 3D direct laser writing (DLW) technique developed by Nanoscribe is used to fabricate a model of a cell membrane. In this study, we report the technological aspect of Nanoscribe and its application of the physical concept of two-photon polymerization. This process prints three-dimensional structures for various applications in the nanometer and micrometer scale. Various parameters of Nanoscribe were investigated in order to print large structures to fabricate microfluidic devices efficiently and in fine detail. The new 3D printing application of Nanoscribe may allow for more dynamic fabrication of microfluidic devices in future investigations. The model of a cell membrane will be used in modeling a tumor microenvironment by the fabrication of a three-dimensional microfluidic device, specifically, a three-dimensional microfluidic cell array (3D Î¼FCA) for the purpose of culturing and co-culturing cells. The three-dimensional microfluidic cell array consists of three layers: micro-channels, cell membrane, and micro-chambers. The cell membrane is the middle layer of the 3D Î¼FCA consisting of an array of clustered pores at specific locations which will guide the diffusion of fluids in between the microchannels (top layer) and microchambers (bottom layer).

CLIMATOLOGY, OCEANOGRAPHY and GEOPHYSICS

Modeling the relationship between Giant Kelp and ocean surface currents

Margo Accettura - Skidmore College

Macrosystis pryifera, also known as giant kelp, is the predominant kelp species found in the Southern California Bight. Kelp commonly grow in dense aggregates known as `kelp forests` which enable them to be observed via remote sensing. In addition to their ecological impacts on coastal systems, kelp forests alter ocean currents with which they come into contact. The primary goal of this study was to create a system to visualize and ultimately model the relationship between kelp forest shape and ocean surface currents. This initially involved selecting a kelp forest location within the Santa Barbara Channel, between Coal Oil Point and Campus Point, where kelp forests persist continually and changes in kelp forest shape are readily detected. Unsupervised classifications were then used to create visual representations of kelp forest shapes using monthly LandSat images extending from 2011 to present. Monthly averages of surface current data, measured as part of Coastal Ocean Currents Monitoring Program (COCMP), were then overlaid on top of unsupervised classification images. These images were arranged into a time series showing the evolution of both kelp forest shape and surface current over time. This methodology could potentially allow not only the modeling of the effects of kelp shape and area on the direction and magnitude of surface currents, but also nutrient transport into and out of kelp forests.

Study on the Deterioration and Possible Renewal of an Earth-Fill Dam

Victoria Grover - Adelphi University

In the early 18th century, dams began to grow in number and prominence across the American landscape. Today, the American populace relies heavily on irrigation, reservoirs, and hydroelectric power that is made possible by the damming of mighty rivers. While larger specimens such as the Hoover Dam are well recognized, countless smaller structures of a similar nature have also been constructed. These dams belong to "Class AA, classified as such because these dams pose a negligible threat to people and property were they to fail. Class AA dams are often found on private properties holding back small ponds or streams in order to create a freshwater environment for native species. One such dam exists alongside Sunset Road in the Westerlo township of Albany County and the possible methods that can be implemented to ensure its continuing stability and usage. "

Examining the Changes in The Tornado Debris Signature with different Debris Types

Allison LaFleur - Lyndon State College

This research examines how differential reflectivity (ZDR), correlation coefficient (RHOHV), and reflectivity (DBZ) change as a tornado interacts with different types of debris. High resolution mobile Doppler radar data and a detailed aerial damage survey of the 2013 El Reno OK tornado are used to examine these variables along the damage path over vegetative fields and when the tornado impacts houses and buildings. An initial qualitative analysis was done to visualize how ZDR, RHOHV, and DBZ change over time inside the tornadic debris signature (TDS). A statistical analysis of 13 different times was performed to determine exactly how the different variables changed over time. After the tornado hits the houses the ZDR and RHOHV values decrease and the reflectivity increases. The RHOHV values decrease because leaves and dirt and other light debris has a more uniform shape than larger debris such as houses. The ZDR values depress for a similar reason as larger debris has more of a random orientation than grass and other smaller debris. A comparison was also done between areas of the TDS with reflectivity greater than 40 DBZ and less than 40 DBZ. The impact of debris types on the radar couplet is examined by measuring the change of the zero-line orientation before and after the tornado encountered buildings and structures. The analysis shows that the radar couplet becomes more divergent after the tornado encounters building and structures suggesting larger debris centrifuging by the tornado.

MATHEMATICAL PHYSICS

Fractal Analysis of Diffraction and Interference Patterns
Christina Hibner - Manhattan College
Fractal analysis was conducted on the interference patterns of sound waves traveling through Chladni plates. Images of these patterns were run through a program that used box counting to analyze it`s fractal dimension. It was found that as the images progressed diagonally, the fractal dimension increased and the lacunarity decreased.

ATOMIC, OPTICAL and MOLECULAR PHYSICS

Precise measurement of the 8p1/2 hyperfine splitting in thallium 203 and thallium 205 using two-step laser spectroscopy
Sauman Cheng - Williams College
We use two-step, two-colour, laser spectroscopy to measure the hyperfine splitting of the 8p1/2 excited state in thallium-203- and thallium-205, as well as the isotope shift of the 7s1/2 to 8p1/2 transition. The ns^2np^1 multi-valence electron structure of thallium is at once simple enough for theoretical treatment, and sufficiently complex for precise measurements of its atomic properties to be a valuable test of the approximation techniques used in state-of-the-art atomic theory calculations. Furthermore, a better understanding of the atomic structure of heavy atoms stemming from quantum mechanical effects will allow for tests of fundamental particle physics of and beyond the Standard Model. In this experiment, we spatially overlap two laser beams through a vapour cell with both thallium isotopes, the first frequency locked to the 6p1/2-7s1/2 378 nm UV transition, the second scanned across the 7s1/2-8p1/2 672 nm red transitions. The resulting Doppler-free spectrum is detected with the assistance of a lock-in amplifier. The frequency scale is calibrated with the combination of a Fabry-Prot interferometer and radio-frequency modulation of the red laser beam with an electro-optic modulator to produce side-bands in the spectrum.

DarkSide-50 electron recoil energy deposition
Rory Fitzpatrick - Princeton University
Energy depositions in DarkSide-50 are recorded in two inversely proportional components: scintillation (S1) and ionization (S2). The rate of recombination between Ar is dependent on the strength of the drift field so the light yield can be determined by varying the drift field and fitting the result to a model for energy light yield. Light yield can also be determined by studying single electron scatters in the apparatus. The results from these two studies are no consistent. Here we seek to reconcile the inconsistencies in the energy variable model.

Simulation Study of DRMI Lock Acquisition in Advanced LIGO
Rebecca Li - Gordon College

Lock acquisition is the process of bringing each optic in the interferometer to its operating point. In advanced LIGO, the implementation of the Dual-Recycled Michelson Interferometer (DRMI) adds difficulties to lock acquisition due to the fact that individual cavity length signals in DRMI are highly non-linear and cross-coupled. In addition, several parameters like the choice of triggering signals, triggering threshold values, and filter shapes that have significant impacts on DRMI lock acquisition have been determined empirically and not well understood. In this project, we develop a numerical simulation of advanced LIGO using the End-To-End time domain module under realistic constrains while acquiring the flexibility of modifying the control system to study the locking behavior under different conditions. Using the simulation, we investigate the influence of possible parameters and search for the optimum method of DRMI lock acquisition.

Generating vector vortex beams with q-plates
Sandra Mamani - City University of New York Lehman College
Vector vortex beams are optical beams with a changing polarization topology around the circumference of the beam. The net orbital angular momentum content of these beams could be zero or an integer value. In this study, we generate both scalar and vector vortices with a q-plate. The q-plate is a patterned liquid crystal, which converts spin angular momentum of light to orbital angular momentum of light. The polarization topologies that we have generated include optical vortices with circular polarization, azimuthal polarization, and radial polarization. I will present some of the work that we are doing with vector vortex beams that is generated with the q-plate.

Geometrically Protected Resonance Modes and Optical Fano Resonances
Emma Regan - Wellesley College
Traditionally, photonic crystal slabs consist of a high-index guiding layer with periodic index contrast. These structures can support guided resonances that are strongly confined to the slab but can also couple to external radiation. The ability to channel light from the slab to the external environment has been used in optical devices, such as photonic-crystal-based light-emitting diodes. However, when a photonic crystal slab is placed on a substrate, the resonance modes couple to the substrate, reducing the interaction with external radiation. To avoid this problem, plasmonics and high-index dielectrics are used, but both are lossy, especially at short wavelength regime (such as visible wavelengths). Using the scale structure of the Diane Juno butterfly as inspiration, we present a low-index zigzag surface structure that supports guided resonance modes regardless of the substrate dielectric constant. We model an acrylic zigzag structure on various substrates using the finite difference time domain method. The resonance modes and corresponding Fano resonance peaks remain for substrate with large dielectric constants, which was not previously possible. The zigzag structure supports guided resonances that are contained away from the substrate, which reduces the coupling and geometrically protects the resonance modes. To experimentally verify the protected resonance property, the zigzag was used to generate structural color on a substrate with approximately equal dielectric constant. Zigzag structures were optimized to produce a Fano reflection peak in the visible spectrum and fabricated on a fused silica substrate using direct laser writing. Normal incidence reflection was measured with a microspectrometer and agrees well with predicted spectra, indicating that the resonance modes are geometrically protected by the zigzag structure.

Characterization of a home-built NOPA with a low dispersion FROG spectrometer
Hope Whitelock - University of Connecticut
A low dispersion frequency-resolved optical gating (FROG) spectrometer was designed to characterize ultrashort (<50 femtosecond) laser pulses from a commercial optical parametric amplifier, and a home-built non-colinear optical parametric amplifier (NOPA). This instrument splits a laser pulse into two replicas with a 90:10 intensity ratio using a thin pellicle beam-splitter, and recombines the pulses in a birefringent medium. The instrument detects a wavelength-sensitive change in polarization of the weak probe pulse in the presence of the stronger pump pulse inside the birefringent medium as a time-delay between the pulses is scanned. This allows for characterization of the frequency-and time-content of

ultrafast laser pulses, which is needed for interpretation of experimental results obtained from this laser system.

Optically Detected Magnetic Resonance Measurements of Nitrogen-Vacancy Centers

Carina Belvin - Wellesley College

Nitrogen-vacancy (NV) centers in diamond are promising candidates for qubits. The electronic ground state of an NV center is a spin triplet and has the spin sublevels ms = 0 and ms = ?1, which can function as the two states of the qubit. By applying microwave radiation at the frequency of the transition between these two spin states (2.87 GHz), we can alter the spin state of the NV center, and then read out the spin state optically. We have constructed a setup for performing optically detected magnetic resonance (ODMR) measurements on ensembles of NV centers in diamond nanocrystals.

Precise Measurement of the Stark Shift in the Indium 6P1/2 State Using Two-Step Laser Spectroscopy

Allison Carter - Williams College

Group IIIa atoms provide a particularly interesting opportunity in atomic physics; they are more complex and less well understood than hydrogenic atoms, but the theory describing them is simple enough to study. By making measurements of atomic structure with a greater level of precision than the predictions current atomic theory, we provide information that allows theorists to improve their approximations, and thus obtain a more comprehensive understanding of quantum mechanics of atoms. These atoms can also be used to test for physics beyond the Standard Model when the quantum mechanics is well known. We specifically look at the Stark shift in indium. In this poster, we discuss a new laser locking scheme and our preliminary data.

Trap State Measurements in Semiconducting Quantum Dots

Elizabeth Dresselhaus - University of Pennsylvania

Quantum dots (QDs) are nano-scale structures whose optical and electronic properties are highly dependent on their size. They exhibit strong photo absorbance in the solar range and have potential applications in photovoltaic cells. However, the conduction of these materials is poor in their current state. Trap states hamper charge flow and decrease power efficiency of QD devices. Quantifying the energy of the trap states may suggest new dopants to incorporate into devices. To this end, my research uses Thermal Admittance Spectroscopy to quantify the trap state energies of PbS quantum dot films.

Analysis of Coulomb interaction in 2 and 3 dimensional two-body systems

Dominika Palinko - City University of New York Borough of Manhattan Community College

Nano-science is one of the fastest growing fields in both physics and engineering. It is now possible to design and fabricate devices whose physical dimensions are on the nanometer scale and whose quantum properties can be tuned as desired. Computing eigenvalues and eigenfunctions of the Schrodinger equation for the exotic kaonic, hydrogen and positronium atoms by ND solve method is very simple and fast. We can also implement this method for two dimensional systems. In two dimensions, the ground state of hydrogen atom and the exciton are computed for the screening Coulomb interaction. An arbitrary initial solution and an eigenvalue are first assumed. In two dimensions the computations include the ground and excited states. This method is faster than the matrix method and the variational methods.

Toward a Graphene-based Quantum Point Contact

Grace Pan - Yale University

Quantum point contacts (QPCs) are narrow constrictions on the order of the Fermi wavelength that bridge together two electrically conducting regions. QPCs display sensitive conductance quantization and are a classic playing field to illustrate clean, ballistic transport in low-dimensional materials. However, graphene-based QPCs are challenging to fabricate, in part due to two reasons: edge disorder that suppresses conductance quantization and imperfect gate depletion leading to charge puddles. Using graphene-boron nitride heterostructures, we demonstrate improvements over a simple etch and Au-gating method by introducing a protective alumina dielectric layer. We use this method to create two QPCs in series and explore potential electron-beam collimation at low magnetic field, in the spirit of Molenkamp (1990).

It`s a Trap! Preparing to Trap and Cool 40Ca+

Ariel Silbert - Williams College

The long-term experimental goal of Professor Charlie Doret`s lab is to use trapped calcium ions to study other quantum mechanical systems. In order to ionize, cool, trap, and view the atoms, we will need an assembly involving lasers with very stable and accurate frequencies, a low-pressure vacuum chamber, and an imaging system.