2015 APS CUWiP at the Research Triangle, NC
Research Presentations

Saturday, January 17 -- 4:00-5:30pm

Note: Research talks will be held in two concurrent sessions. Each presentation will be approximately 12 minutes, and each presenter will have 3 minutes after their talk to answer any questions.

RESEARCH TALKS: SESSION 1
White Lecture Hall 107
Chair: Katrina Miller

4:00-4:15 Ashlyn Burch, Georgia College & State University/Duke University
Silicon Strip Detector Research and Development for the LHC
ATLAS at CERN is scheduled to replace all inner tracking within the inner detector with silicon. In collaboration with ATLAS, we are constructing a silicon strip module with a water cooling system at Duke University. It uses an ABCN-25 chip that was originally designed for prototype testing. We run IDelay, Strobe Delay and Noise Occupancy scans through SCTDAQ software using a single chip module at Duke University and a complete module setup at ATLAS to determine detector luminosity and processing. Our aim is to develop an ASIC with readout for the silicon strips that is cost-effective and more resistant to radiation.

4:15-4:30 Keely Criddle, James Madison University
Mechanical Properties of Hydrogel Beads
Fragile solids made of dense disordered packing of bubbles, droplets and grains are able to withstand small stresses by virtue of system-wide force chains that lock the system into a jammed state. The nature of the jamming transition in such soft materials has been the subject of intense research, but despite much effort, a deep understanding remains elusive. In this experiment we study the mechanical properties of hydrogel beads to exploit them as force transducers in densely packed systems. The experiment consists of applying uniaxial planar compressions on the beads, and correlating the force to the bead's strain and contact area. The results show that while the strain scales linearly with the diameter of the contact area, the force and strain are found to obey a power law relation with two distinct exponents at small and large strains. This result leads to a power law dependence of the force on the contact area diameter of the compressed bead.

4:30-4:45 Mithi de los Reyes, North Carolina State University
Ring Finding Algorithms for the NA62 Level 1 Trigger Software
In the Standard Model, the CKM matrix accounts for some amount of charge-parity violation. The NA62 experiment at CERN intends to measure “ultra-rare” kaon decay modes in an attempt to precisely measure one of the elements of this matrix. This requires an efficient trigger system to reject background events without losing signal. Here, we investigate the high level trigger software. In particular, we study the trigger conditions for the ring-imaging Cherenkov detector and develop ring-finding algorithms to make multiplicity cuts.

4:45-5:00 Melody Lim, Duke University
Forces and flows during high speed impacts on a non-Newtonian suspension
A suspension made of starch particles dispersed in water displays significant non-Newtonian behavior for high enough particulate concentration. We observe a shock-like propagation in the cornstarch suspension during impact. Although the dynamics of this shockfront are strongly correlated to the dynamics of the intruder, we find that a simple process of

momentum transfer to the suspension is insufficient to account for the force experienced by the impactor. Additionally, we observe an extremely fast timescale associated with the propagation of forces to the boundaries of the suspension. This timescale precedes bulk motion of the suspension, suggesting the existence of a very fast front which has not been previously reported. Changes in the timing and magnitude of force propagation to the boundaries reveal transitions in the behavior of the suspension at two critical velocities.

5:00-5:15 Meg Stuart, University of Tennessee

Probing the Quark Gluon Plasma: Background Subtraction Methods

The theory of quantum chromodynamics predicts the existence of the Quark Gluon Plasma at high energy density. At very high energies, the strong force binding quarks and gluons into nucleons breaks down and nucleon bounds become irrelevant. The QGP is produced by and studied at the Large Hadron Collider at CERN. To explore the medium's properties, scientists must measure how the medium alters jets traveling through it. This alteration, or suppression, can be seen through the loss of momentum and spreading of particles produced by a jet due to interactions with the nuclear matter. The problem with measuring jet suppression is the existence of a huge background of low momentum particles that are not part of the jet. This poses a problem with analysis, so I have been developing and testing a previously untested model for background subtraction and applying it to simulated data.

5:15-5:30 Grace Watt, Davidson College

Understanding LED Function and Exploring Mechanisms of Energy Loss

In today's blue light emitting diodes (LEDs), the efficiency of light emission decreases as the electric supply energy is increased beyond a relatively low threshold. Since the energy is dissipated as light or heat, measurement of both components along with operational time-dependent phenomena can provide clues about the underlying reasons for energy loss. We describe how light is generated in LEDs and we investigate the electronic properties of blue LEDs in order to identify features related to energy loss.

RESEARCH TALKS: SESSION 2

East Duke 209

Chair: Danielle Riggin

4:00-4:15 Marie Blatnik, Cleveland State University/North Carolina State University

The Hadron-Blind Ring-Imaging Cherenkov Detector

High-energy nuclear collision experiments use a combination of tracking detectors and calorimetry to form large momentum and energy spectrometers that identify and track particles after a collision. Particle identification at higher energies where the particle's mass is negligible in comparison with the particle's total energy becomes increasingly difficult as the particle's velocity approaches the speed of light. These spectrometers must evolve as the physics criteria advances such as in the case of the proposed Electron Ion Collider (EIC). The EIC's beam energies, required to probe the mysteries of the exploding gluon density at low parton momentum fraction and the hypothesized color glass condensate, will produce hadrons that leave the collision site at up to 100 GeV. A ring-imaging Cerenkov detector is being developed for this tricky particle identification, which uses a CsI photocathode, Gas Electron Multipliers (GEMs), and a MgFl coated spherical mirror to detect and focus Cerenkov photons. These photons and the rings they trace are the key to particle identification in this energy regime. Results from the construction tests and beam tests of a prototype will be presented, including the detector's response to 7 GeV electrons from the Stanford Linear Accelerator and 20 GeV, 25 GeV, and 32 GeV positively-charged hadrons from the Fermilab M-Test facility.

4:15-4:30 Sarah Burnett, University of North Carolina at Chapel Hill

Diffusion of a Passive Scalar in Taylor Pipe Flow

In two-dimensional channel models and three-dimensional circular- and square-faced model glass pipes, we explore the theory of Taylor dispersion explaining the motion of a passive scalar transported by laminar flow. Through experiments we observe a fluorescein-dyed portion of deionized water move through a radially symmetric pipe at different rates determined by the dimensionless Péclet number. Depending on the characteristic length and mean velocity, we observe the effects of Poiseuille flow as either advection or diffusion dominates at different regimes characterized by the Taylor time scale. In analysis of the experimental data, we strive to find the three-dimensional concentration of the dye plug inside the cylindrical pipe using the intensity from two-dimensional photographs. This research is fundamental in many fields such as medicine where we could better understand the transport of microfluidic and nanofluidic devices and hydraulics.

4:30-4:45 Emily Kuhn, Duke University

Development of a Magnetic Trap

Quantum computing is rapidly becoming one of the most exciting frontiers in physics and engineering. One proposed method of building a quantum computer is to encode information in the energy levels of a neutral atom, which requires atom trapping. I designed a magnetic trap in order to trap a cloud of rubidium 87 atoms. This trap uses a quadrupole magnetic field generated by anti-Helmholtz coils, which exploits the Zeeman effect in order to force the atoms to the vacuum cell's center. I will discuss the design of a general MOT, the techniques I used to trap with this magnetic trap and the different constraints I had to work within. This trap will ultimately wind up as a part of Margaret Shea's PhD research experiment.

4:45-5:00 Brigid McDonald, University of Virginia

Comparison of BSGI and DMT Breast Imaging Techniques using Gelatin and Point-Source Phantoms

Breast-specific gamma imaging (BSGI) is an imaging technique that uses gamma rays to detect the presence of a radioactive tracer, which tends to accumulate preferentially at the site of a tumor. Dual modality breast tomosynthesis (DMT) is a novel breast imaging system that combines BSGI with mammography (x-ray imaging) and tomosynthesis (3-D imaging). DMT takes both x-ray and gamma-ray images at several angles in succession, producing a 3-D image that provides both structural and functional information. In this study, the two imaging techniques were compared by imaging gelatin and point-source phantoms on a Dilon BSGI scanner and a DMT scanner built in the lab. DMT was found to improve the spatial resolution and lesion detection sensitivity of phantom images compared to BSGI. Although neither technique was able to detect small lesions far from the camera, DMT was shown to increase count sensitivity for lesions of all sizes. DMT also reduced blurring for points at all distances away from the camera. DMT's improved image quality and ability to produce 3-dimensional images suggests that it is a favorable alternative to BSGI.

5:00-5:15 Krista Smith, University of North Carolina at Charlotte

Gamma-Ray Burst Redshifts Could Indicate Non-Uniformity and Structure Within Universe

We study all gamma-ray bursts (GRBs) with spectroscopic-confirmed redshifts observed between the dates of November 20, 2004 through July 2, 2014, and look for patterns of potentially non-random behavior. Such behavior might consist of clusters of GRBs in certain BAT RA and Dec coordinates, or clustering within certain redshift intervals. Additionally, we look for areas in the sky that might have greater GRB activity than others, or conversely, certain areas that have significantly less activity. The method used to search for correlation was a traditional counting approach initially done by hand, but after preliminary testing yielded interesting results, a code in the python language was written to implement the method. We analyze the data for peaks in GRB activity beyond three standard deviations from the mean. At this time, we do not offer theoretical explanations for the results presented here.

Sunday, January 18 -- 1:00-2:15pm

POSTER PRESENTATIONS
Jameson Gallery, Friedl building

Kelly Archer, Georgia College & State University
The Development of Software for Web-Based Control of The Georgia PEAcH
We are developing a program for web-based control of the Georgia PEAcH, which is the portable electrostatic ion accelerator we are constructing in collaboration with the University of North Georgia. It is being coded in Python and run on a Raspberry Pi computer. While the Georgia PEAcH is being constructed the program is being coded to control a 10 inch telescope and will later be adapted for the accelerator. The program will be separated into three modules of code: communications between the accelerator and the Raspberry Pi, a user interface, and an extension of the user interface hosted on a website which will allow remote access to the controls of the Georgia PEAcH. The progress on coding the program to control a telescope and plans for future adaptation to run the Georgia PEAcH will be presented.

Genesis Ayala de Leon, University of Puerto Rico - Humacao
Electrochemical Double Layer Capacitors with Carbon Composite Electrodes
Electrochemical double layer capacitors (EDLCs) are one of the most promising energy-storing devices due to their environmental friendliness, high power density, rapid charging/discharging ability, and long cycle life. In EDLCs, two electrodes are placed in an electrolyte and a voltage is applied between them, forming an electrochemical double layer on both electrodes. They have the high storage capacity of batteries and the fast charging characteristics of capacitors. The capacitance of these devices is determined by the specific surface area and electrical conductivity of electrode materials. In the first phase of this research, the electrodes were prepared by mixing and sonicating a solution containing 90 wt% Activated Carbon (AC), and 10 wt% polystyrene (PS) in chloroform ($CHCl_3$) as the binder. An amount of 0.15 wt% Carbon Nanotubes (CNTs) and 1.5 wt% of the surfactant sodium dodecyl-benzene-sulfonate (SDBS) was added to the solution. A flexible and simple EDLC was constructed by inserting two electrodes coated to the nickel foam and a piece of filter paper between them (separator) inside a small seal bag with KOH (6 M) as the aqueous electrolyte. Its properties were analyzed using scanning electron microcopy (SEM), electrical conductivity measurements, and energy-dispersive x-ray spectroscopy (EDS). The capacitance of the EDLC was measured using the constant current discharge method. Results showed an improvement in the performance of the EDLC with the addition of CNTs. The addition of SDBS increased the conductivity of the electrode but the EDLC failed and no capacitance was measured. The second phase consisted in studying the influence of SDBS in the porosity of the electrodes. The percentage of PS added to the samples was reduced to 1 wt%. Their properties were analyzed using SEM, electrical conductivity measurements, and EDS. Results showed an increment of the electrodes porosity, but a readily reduction of its conductivity.

Haley Bauser, College of William & Mary
Creating Organic Solar Cells Made from Titanyl Phthalocyanine Nanoparticles and Semiconducting Polymers
Organic solar cells, while not as efficient as their inorganic counterparts, are a valuable complementary platform for sources of renewable energy due to their flexibility and lower production cost. Organic solar cells have a transparent anode, and active layer, and a cathode. Traditionally, the active layer consists of a polymer-fullerene blend (such as P3HT-PCBM). What makes our organic solar cells unique is the active layer comprised of a blend of titanic phthalocyanine nanoparticles and an N2200 polymer. This material combination absorbs a wider range of the solar spectrum than the traditional P3HT-PCBM. It's also advantageous in achieving and stabilizing an ideal phase separation structure, leading to improved device efficiency and enhanced lifetime.

Sara Berry, North Carolina State University
Radar Observations of Storms for Education

Simple 2D schematics of thunderstorms are often used in meteorology classes to describe the structure of storms. While useful to explain basic concepts, these static 2-D depictions of storms are very limited and incomplete descriptions of what actually occurs in the life-cycle of a thunderstorm. Output from three dimensional numerical models are also used in class to describe storm evolution but do not adequately communicate the complexity of real storms. We aim to complement these resources by building modules on thunderstorm structure based on research radar data. We obtained radar data from the CSU CHILL and NCAR S-Pol radars located in Colorado at the foothills of the Rocky Mountains. Undergraduate students remotely operated both radars in coordinated scans from our laboratory at North Carolina State University. Data were collected from 18 storms between May 20 and June 20, 2014. A scan strategy consisting of a volume scan and vertical cross-sections was executed every 3 minutes. We frequently updated the locations of the vertical cross sections to maintain focus on key areas of interest as the storm evolved and moved. We use the dual polarization variables collected by the radar to identify the hydrometeor type within the storms. The final education modules will feature three-dimensional depictions of thunderstorm structure, winds, and precipitation type as the storms evolve.

Ashlyn Burch, Georgia College & State University/Duke University
Silicon Strip Detector Research and Development for the LHC
ATLAS at CERN is scheduled to replace all inner tracking within the inner detector with silicon. In collaboration with ATLAS, we are constructing a silicon strip module with a water cooling system at Duke University. It uses an ABCN-25 chip that was originally designed for prototype testing. We run IDelay, Strobe Delay and Noise Occupancy scans through SCTDAQ software using a single chip module at Duke University and a complete module setup at ATLAS to determine detector luminosity and processing. Our aim is to develop an ASIC with readout for the silicon strips that is cost-effective and more resistant to radiation.

Sarah Burnett, University of North Carolina Chapel Hill
Gravity Driven Particle-laden Slurries
We present new experimental and theoretical results for the resuspension of bidisperse particle-laden flows on an inclined plane. In particular, we study the case of two negatively buoyant particle species of similar size and dissimilar densities in a viscous fluid of finite volume. Different regimes of particle separation are observed and studied by adjusting the angle of inclination, total particle concentration, and relative particle volume ratio. In addition to obtaining information about the height profile of shock formations, we measure the advancement and separation of particle and fluid front positions in mono- and bidisperse scenarios. These dynamics are the basis for a quantitative understanding of polydisperse cases, which can be readily applied to industry and catastrophe modeling.

Eve Chase, College of William & Mary
Wavelet Graph Searches for Gravitational Chirps
As gravitational wave detector sensitivity increases with second generation interferometers, direct detection of gravitational waves is increasingly more probable, with gravitational chirps from inspiraling merges between black hole and/or neutron star binary systems as the most probable source. Robust, efficient, and accurate data analysis methods are required to detect gravitational chirps. We provide a method for the production of a combined graph, representing numerous possible gravitational chirps within a wide range of times of coalescence and masses of the binary components. Interferometer data is searched along the directions of chirps in the graph, to locate chirps in transient oscillatory signals, in hopes of making the first direct detection of gravitational waves.

Nicole Creange, James Madison University
Understanding the optical and electrical responses to Ga-doped Graphene
We simulate the optical and electrical responses in gallium-doped graphene. Using density functional theory with a local density approximation, we show the effects of impurity doping (0-3.91%) on the electron density, refractive

index, optical conductivity, and extinction coefficient for each doping percentages. Here, gallium atoms are placed randomly (using a 5-point average) throughout a 128-atom sheet of graphene. These calculations demonstrate the effects of hole doping due to direct atomic substitution, where we find a disruption in the electron density for small doping levels, which is due to impurity scattering of the electrons. However, the system continues to produce metallic or semi-metallic behavior with increasing doping levels. These calculations are compared to a purely theoretical 100% Ga sheet for comparison of conductivity. Furthermore, we examine the change in the electronic band structure and density of states, where the introduction of gallium electronic bands produces a shift in the electron bands and dissolves the characteristic Dirac cone within graphene, which leads to better electron mobility.

Mithi de los Reyes, North Carolina State University
Effects of Crease Number on Hysteresis of Folded Polymer Sheets
Folded polymer tubes have previously been shown to display stress-strain curves with hysteretic loops, similar to the elastic hysteresis displayed by shape-memory alloys. Here, we aim to isolate the folding dynamics by considering the compression and extension of creased accordion-like sheets. We vary the number of creases and use an Instron to measure stress-strain curves of the sheets. We are unable to observe hysteresis, potentially because sheets are unable to snap through to stable configurations. However, we find that each fold acts like a spring, and that the distance between creases is analogous to the spring constant. Finally, we identify several outstanding questions about the folding of polymer sheets, particularly regarding the characteristic length scale of the sheets and the shape of a single crease.

Dmitrius Denize & Cristalei Polk, Georgia College & State University
Atomic Molecular Optics Laboratory
An Atomic and Molecular Optical (AMO) Physics research lab is an excellent tool to train and mentor undergraduate students in advanced laboratory techniques. Students gain valuable basic experience in experimental designs, data acquisition techniques, working with high precision optical equipment, building electronics, and working in the machine shop. Current projects include machining a laser mount and constructing a current supply circuit and temperature controller for a slave laser. Completed projects involved milling the vacuum chamber mounts to support the chamber, and machining Helmholtz coils for the chamber, which is being used to trap the atoms in a Magneto Optical Trap (MOT). This included designing, building and baking out the vacuum chamber, constructing a Rb getter for the chamber, and building the lasers for a saturation-absorption system that is used to probe the 52S1/2→ 52P3/2 hyperfine energy transitions of the Rb-85 atom. These energy transitions will be used to frequency-lock a diode laser to trap Rb-85 atoms and then cool them to ultra-low temperatures. The atom cooling will permit observation and measurement of the fundamental properties of atoms. This lab has mentored and supported over ten undergraduate students in the last four years, of which one became a High School Teacher, three joined Ph.D. programs, and one went to optometry school.

Natalie Foster, University of Florida
Calibration of High Resolution X-Ray Detectors on FOXSI
The objective of the Focusing Optics X-ray Solar Imager (FOXSI) is to obtain high sensitivity and images with a large imaging dynamic range of hard x-rays present in solar flares. Through NASA's Low Cost Access to Space program, it was made possible to send several DSSD's (double-sided silicon strip detectors) on board a sounding rocket to carry out these observations in order to better understand the nature of particle acceleration at the Sun. FOXSI also aims to image hard solar x-rays using direct focusing optics, rather than indirect techniques that have previously been used, with the advantage of an increased sensitivity. The detectors were donated by the Astro-H group at ISAS/JAXA and meet the requirements of fast readout times necessary for FOXSI observations due to the low-powered ASIC readout system. Using radioactive sources with known emission spectra, the detectors were calibrated. This accounts for the individual response of each channel on each detector for improved spatial and energy resolution. On December 11, 2014, some of these calibrated detectors were flown for a second time from the White Sands Missile Range, and have demonstrated their functionality with brand new data obtained from three active regions of the Sun, as well as one quiet region.

Nykesha S. Fyffe, Appalachian State University

Techniques on Developing Fluidic Devices

A fluidic device is used to create a bond between myosin and actin coated beads. The beads are the material that is placed within the sample chamber and the myosin is the material that is being moved throughout the system. Myosin and actin are attracted to each other and myosin can act as an arm connecting the two beads together which will exert a force that we are looking to measure and observe. Myosin and actin are two components that contribute to muscle contraction. Weak muscle contractions can lead to a weak heart; observing the bond between the two materials could provide more information on muscles in the human body. A fluidic device is used to control the flow of fluids into a specified area by manipulating pressure and maintaining the same concentration of fluids within the chamber at all times. A control system is connected to both a computer and a pressure gauge. A vial chamber is connected to the system that holds the fluids that are being manipulated. The amount of pressure that is put into this system can be varied and will affect the fluid. The fluidic device is designed to handle small scaled materials, myosin, and combine them with a different material, actin coated beads. My poster will be presenting the schematics of the fluidic device and how it will work.

Melissa Guidry, College of William & Mary

Toward characterizing bioluminescence on a single-photon level

The reaction between luciferin and ATP with catalysis from the enzyme luciferase results in the emission of a single photon. It has been seen to exhibit low cytotoxicity, resulting in development of biological probes for imaging. NIST's unique tools will allow in depth study of the kinetics and single-photon nature of the reaction. A specialized flow cell and optics system were created to allow single-molecule scope. The cell was designed to allow efficient plate replacement, as well as constant control of reactants over immobilized luciferin. The optics system was designed to take in as much light as possible with available materials, as the reaction emits in all radial directions. A knife-edge technique was used to characterize the optics system. A silvered and nano-etched fiber was built to operate as a point source to allow better representation of the optical throughput. Further studies are necessary to determine an optimal setup.

Angela Harper, Wake Forest University

Active Site Profile Based Clustering of the Peroxiredoxin Superfamily

Protein function is often predicted based on sequence similarity, leading to misannotations and propagation of incorrect annotations of proteins. The Structure Function Linkage Database (SFLD) is considered by many to be the gold standard for protein annotation due to manual curation. However, manual curation is expensive and time-consuming, so automated processes for precise annotation and functional clustering are imperative. The Peroxiredoxin (Prx) superfamily has been extensively studied by experts, making this an appropriate baseline for functional clustering. Using the Prx superfamily, parameters were defined for determining discrete and functionally relevant groups of proteins within a superfamily. The Deacon Active Site Profiler (DASP), previously developed by our lab, extracts residues around an active site environment of a protein, creating its unique signature. Our lab recently developed a process called TuLIP which, using DASP, functionally clusters all structurally characterized members of a superfamily according to their active site environment. The Prx superfamily was split into four distinct TuLIP groups. The signatures from these groups are aligned by DASP, and subsequently, GenBankNR is searched for proteins with similar active site features. Iteratively searching GenBankNR resulted in gathering information about the active site relationship of the Prx superfamily. This process created functionally relevant, discrete groups in which no protein is assigned to two different groups at significant scores. Additionally, TuLIP groups containing multiple subgroups were split into the appropriate functionally relevant subgroups as defined by the SFLD. This method of functional clustering is both accurate and automatable, which will aid future efforts to create a fully automated process for annotating further superfamilies.

Mary Elizabeth Lee, Georgia Institute of Technology

Chaotic dynamics of a candle oscillator

We investigate the dynamics of a popular science experiment known as the "candle see-saw" in which a candle is free to oscillate vertically around a rod running through its center. When lit at both ends, the dripping wax creates nonlinear forcing that drives complex dynamics whereby the candle can "flip over the top" and display irregular reversals in its direction of rotation. We describe our experimental setup, characterize the nonlinear forcing and search for signatures of chaotic behavior in our data.

Emily Kuhn, Duke University

Development of a Magnetic Trap

Quantum computing is rapidly becoming one of the most exciting frontiers in physics and engineering. One proposed method of building a quantum computer is to encode information in the energy levels of a neutral atom, which requires atom trapping. I designed a magnetic trap in order to trap a cloud of rubidium 87 atoms. This trap uses a quadrupole magnetic field generated by anti-Helmholtz coils, which exploits the Zeeman effect in order to force the atoms to the vacuum cell's center. I will discuss the design of a general MOT, the techniques I used to trap with this magnetic trap and the different constraints I had to work within. This trap will ultimately wind up as a part of Margaret Shea's PhD research experiment.

Evyn Lee, Appalachian State University

Microsphere Characterization with Raman-Tweezers

Raman-tweezers is a unique spectroscopy technique that can be used to study microbes within multiple environments. The main goal of our custom-built Raman-tweezers apparatus is the identification and characterization of microbes in fermentation processes. In general, Raman-tweezers can both optically trap particles that are on the micro- to nano-scale size and provide Raman characterization of the trapped object. Our Raman-tweezers apparatus possesses many features that allow for the collection of Raman spectra of many sized samples, along with position sensing for traditional optical tweezers force spectroscopy. General Raman-tweezers methodology, along with preliminary Raman spectra of single trapped dielectric microspheres acquired with our newly designed system, will be presented.

Alexander Mandarino, Appalachian State University

Automation of absolute temperature measurement in optical tweezers

An optical tweezers system uses highly focused laser radiation in order to confine small particles and typically is used to study biological systems or materials. The measurement of the trap stiffness can be completed through various calibration techniques. Many calibration methods require an accurate knowledge of particle size, fluid viscosity, and temperature. We present a method for the automation of position data collection and subsequent high-frequency power spectral analysis to find the temperature of the particle in the optical trap to be used in trap stiffness calibration. The implementation of this method of temperature measurement allows for a more accurate determination of trap stiffness an automated calibration program for optical tweezers systems, which we are currently developing.

Hannah McFarland, James Madison University

Investigating nanopore-based DNA sequencing via electric currents through graphene ribbons

Nanopore-based technology has the potential to be an efficient method for DNA/RNA base sequencing, as well as an identifier of other biomolecules. However, the thickness of the nanopore substrate is critical for the identification of individual nucleobases due to resulting noise and resolution problems. Recently, graphene has been suggested as a possible nanopore substrate due to its single atomic thickness and robust strength. In this study, we examine a possible device mechanism for the voltage dependence of nucleobases passing through a graphene nanopore. We utilize density functional theory with a generalized gradient approach on a graphene ribbon with a nucleobase in order to calculate the transmission spectra for each base. Transmission spectra for each base allows for the calculation of the ballistic current and differential current as a function of voltage. We show that applying various bias voltages across a graphene ribbon for the general, energy-minimized position of the translocated nucleobase, it is possible to distinguish individual bases using the resulting current. Overall, our goal is to improve nanopore design to further DNA/RNA nucleobase sequencing and biomolecule identification techniques. Therefore, we provide a general mechanism for a graphene-based device the can be developed for DNA/RNA sequencing.

Helen Meskhidze, Elon University

Developing an Atlas of Starburst Galaxy Emission Lines

Recent observations of high ionization lines (e.g. [Ne V] and He II 4686) from star-forming regions have prompted a need to study the production mechanisms of these high ionization lines. Our study addresses the following questions: 1. What are specific cloud parameters that influence the strength of emission lines in starburst galaxies? 2. How can these parameters be tuned in simulations to match observations? We adopt the locally optimally emitting cloud model, a model previously used to study AGN, for our study of star-forming regions. We present the results of hundreds of photoionization simulations spanning 15 orders of magnitude in hydrogen ionizing photon flux and 10 orders of magnitude in hydrogen density. We vary both properties of the starbursts (SEDs, evolutionary histories, ages), as well as cloud properties (such as the abundances and metallicity), tracking nearly 100 emission lines ranging from the UV to the near IR. Finally, we compare these results to the results of other studies on star-forming regions. The results of our photoionization calculations should prove useful for the analysis of starburst galaxy emission-line data.

Benjamin Migirditch, Appalachian State University

Raman Spectroscopy: The Theory, Applications and Current Research

Raman Spectroscopy is an optical technique that utilizes Raman scattering to determine the molecular structure of materials. Raman scattering occurs when light of a known wavelength vibrationally excites the molecules of a substance to a higher vibrational energy state. When the molecules return to a lower energy state, light is emitted. About one ten millionth of this emitted light has a different wavelength than the incident light. This shift in wavelength provides information about the molecular structure of a material, because every substance yields its own unique Raman spectrum. Our research frequently uses the spectra of sulfur and isopropyl alcohol for instrument calibration. The applications of Raman Spectroscopy span many different fields, as Raman scattering occurs in both biological and non-biological materials. Current projects include the examination of the structure of biofilms and identification of yeast used in fermentation.

Katrina Miller, Duke University

Development of a Recoil Tracking Detector Capable of Infrared Optical Readout

Gas-based recoil tracking detectors are used for a variety of experiments within nuclear and particle physics to identify unknown particles based upon their interaction with the target gas. Recent research has shown that this technology could be potentially useful in detecting dark matter and understanding coherent neutrino scattering. These tracking detectors collect data via charge collection from ionization of the target gas, and via optical readout by detecting scintillation of the gas. This information is used to reproduce a track image of the momentum of the incident particle. Data from the scintillation effects, rather than charge measurements, provide a more efficient means of creating such track images primarily because radiation signals are not affected by electromagnetic interference in the environment, thereby producing a higher-resolution track image. However, modern scintillation tracking detector technology is still limited by the usage of cameras sensitive only to visible wavelengths. This restricts the target gas to CF_4, because it is the only gas that scintillates in the visible region. Other viable candidates for scintillation, particularly gaseous argon, do not necessarily produce visible light. This research presents the initial stages of design and development of a tracking detector able to utilize gases that scintillate in the near-infrared region. A detector capable of this broadens the number of gases that can be used and provides a longer list of alternatives to present-day tracking detectors.

Gabriela Nieves, University of Puerto Rico - Humacao

Chitosan/PVA Nanofibers with embedded GaN Nanoparticles

Chitosan(CS) /Poly(vinyl)alcohol (PVA) nanofibers containing gallium nitride (GaN) nanoparticles were fabricated using the electrospinning method. Highly crystalline GaN nanoparticles were produced using a combustion technique with ammonia gas ([Chen.et.al.2011]. Appl.Phys A.). The particles were sonicated for an hour at a frequency of 40kHz and centrifuged at a speed of 3,200 rpm to obtain smaller and dispersed particles, then added to a 60/40 CS/PVA polymeric solution, before electrospinning. The GaN nanoparticles and composite nanofibers were characterized using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM)/Energy Dispersive Spectroscopy (EDS), and Photoluminescence (PL). The photoluminescence emission spectra of GaN nanoparticles and composite nanofibers were obtained upon 325 nm excitation wavelength at room temperature. Results show that the emission peeks range from deep UV (310 nm) to the visible light (600 nm). In the future, we plan to enhance the PL properties of the nanofibers by using doped GaN and other nanoparticles, and to study their use for optical applications.

Susan Olmsted, East Tennessee State University

Star Formation in Interacting Galaxies

In our research, we studied the star-forming regions of interacting galaxies and compared to those of normal galaxies. Using UV, optical, and IR archived images in twelve wavelengths from three telescopes, we analyzed samples of star-forming regions in interacting and normal spiral galaxies using photometry. By comparing the luminosities of the star-forming regions in the interacting galaxies to that of normal galaxies, we discovered that the regions in interacting galaxies have higher star formation rates on average.

Gunnar T. Schettler, Appalachian State University

Raman Spectroscopy of Biofilms

Biofilms are collections of microorganisms encased in a matrix composed of extracellular polymeric substances (EPS). These biofilms represent the preferred way of life for most microbial organisms living on Earth. Information regarding the structure and chemical composition of EPS composed matrices could be beneficial to industrial, medical, food and other health related industries, where potentially harmful biofilms may be present. Biofilms account for billions of dollars in lost industrial productivity and are known for causing pipe plugging, corrosion, and water contamination, among others. Gaining a better understanding of biofilm composition could lead to better methods for treating bacterial related diseases and infections, also benefitting other bacterial applications.Raman Spectroscopy offers real time identification and classification of unknown objects using non-invasive optical techniques to gather spectrum that is representative of molecular compositions. Raman spectra are whole-organism spectral fingerprints that can be used to identify different bacteria and can also be used to help determine structure of biofilms. Our current research includes investigations into biofilms composed of vibrio cholera using Raman Spectroscopy as our optical technique.

Hannah Smith, Wake Forest University

Improving Organic Semiconductor Film Formation on Hydrophobic Surfaces Using Protein Complex Treatment

CYTOP is a fluoropolymer dielectric that is commonly used as the gate dielectric material in organic field-effect transistors (OFETs). The hydrophobic nature of this compound often prevents the deposition of solution-based materials that contain a large amount of water or non-fluorinated solvent (e.g. PEDOT:PSS). The application of the protein Avidin has been shown to improve the wettability of hydrophobic surfaces through reducing the water contact angle by exploiting a hydrophobic interaction between the hydrophobic insulator and the hydrophobic regions of the protein. However, Avidin is quite expensive, so to explore a less expensive method of improving CYTOP's wettability, we tested the adsorption of egg whites, which contain Avidin, to CYTOP. We observe that a concentration of one percent egg whites dissolved in H_2O reduce the water contact angle of Cytop from 115 degrees to approximately 60 degrees. Additionally, we observe that the egg white-treated CYTOP films maintained their hydrophilic properties through at least 8 days. We have demonstrated a general technique to improve the wettability of a common hydrophobic insulating material, creating pathways for improving solution processing techniques in OFET research.

Meg Stuart, University of Tennessee

Probing the Quark Gluon Plasma: Background Subtraction Methods

The theory of quantum chromodynamics predicts the existence of the Quark Gluon Plasma at high energy density. At very high energies, the strong force binding quarks and gluons into nucleons breaks down and nucleon bounds become irrelevant. The QGP is produced by and studied at the Large Hadron Collider at CERN. To explore the medium's properties, scientists must measure how the medium alters jets traveling through it. This alteration, or suppression, can be seen through the loss of momentum and spreading of particles produced by a jet due to interactions with the nuclear matter. The problem with measuring jet suppression is the existence of a huge background of low momentum particles that are not part of the jet. This poses a problem with analysis, so I have been developing and testing a previously untested model for background subtraction and applying it to simulated data.

Catherine Witherspoon, James Madison University

A Comparative Study of the Wide-Field Infrared Survey Explorer Properties of Maser & Non-Maser Galaxies in the Mid-Infrared

There is increasing evidence that supermassive black holes (SMBHs) reside in the centers of galaxies, and that their properties are strongly correlated, which suggests the possibility of a co-evolution of SMBHs and their host galaxies. Signs for SMBH growth, or accretion of the surrounding material, are found in the so-called active galactic nuclei (AGNs). A small fraction (4%) of all galaxies also display the exotic 22 GHz water maser emission in their centers, and for a majority of these sources the maser intensity is millions of times stronger than that observed in the Milky Way, thus called megamasers. About 20% of the megamasers are in a disk-like configuration, which makes them extremely valuable for: (1) obtaining the only direct distance measurements to extragalactic sources, offering thus an independent value for the Hubble constant and thus for the geometry of the universe as well as the nature of dark energy, and for (2) providing the most accurate measurements of the masses of SMBHs. While the exact mechanism of water maser emission production is not known, there is tentative evidence that disk masing conditions are associated with AGN activity, and in particular with the potentially obscured AGN. Dusty red AGN remain hidden in their optical signatures, but can be discovered by means of their mid-infrared properties because the AGN heated dust reemits at longer wavelengths. The Wide-Field Infrared Survey Explorer (WISE) provides the largest and best quality database of mid-infrared observations, and we use the WISE public catalogs to investigate the relationship between maser activity, the host galaxy's mid-infrared characteristics, and the associated optical spectral signatures of the degree to which SMBH accretion dominates the energetics. We present new and improved maser detection rates based on the 12m and 22m WISE bands, along with tentative conclusions on the properties of the obscuring material in relation to the maser activity.