9:00 am: An Application of the Modified Picard Method to the Euler Equations

**Author:** Emmett Randel  
**Faculty Mentor:** Dr. James S. Sochacki  

I am interested in looking at alternative solutions to the Euler Equations for an ideal gas (after having experienced the horrors of a finite differencing method), and the modified Picard method can be used to satisfy this interest. The equations are first transformed into a conservation form that gives solutions for the variables of interest (for example density, with the continuity equation $\frac{\partial \rho}{\partial t} = -\frac{\partial}{\partial x}(\rho u)$). This form must also satisfy the theory required for application of the modified Picard method, in that the dependent variables are autonomous and the RHS is polynomial. By rewriting the spacial part of the problem using finite differencing, the equations can be written to meet the necessary conditions. From here, a Taylor series solution is found or an exact solution (as accurate as your symbolic integrator) is found using Picard iteration.

9:15 am: Selecting a capacitor bridge to measure frequency variable dielectric constant.

**Authors:** Eli Klein  
**Faculty Mentor:** Dr. Christopher Hughes  

One of the most commonly used methods of measuring the dielectric constant of a material is to measure the capacitance of a capacitor made out of the material in question. In some cases this can be done with a multimeter, however in many cases it is not appropriate to use digital equipment. This is true if the capacitance of a material varies with the frequency of the current applied to it. In this case, since the capacitance depends on frequency, one must be careful to select the appropriate circuit set-up in which to test the material’s capacitance. We will restrain our scope to the preceding case but hope to touch on a larger, important issue by doing so.

9:30 am: Studying quarks: Particle Detection Methods, Physics Goals

**Author:** Tyler Mullins  
**Faculty Mentor:** Dr. Kevin Giovanetti  

Our research is focused on determining the physical properties of quarks by studying electron – proton collisions at high energies. We observe particle showers by means of electromagnetic calorimetry at Thomas Jefferson National Accelerator Facility, which is undergoing an upgrade to support electron beam energies of 12 GeV. Our current work involves assembling the calorimeter-PMT setup, which will be part of this upgrade.
9:45 am: PMT and Scintillator Testing for the Super High Momentum Spectrometer at Jefferson Lab
Authors: Catherine Nisson, Matthew Burton
Faculty Mentor: Dr. Gabriel Niculescu
The beam energy upgrade (from 6 to 12 GeV) of Jefferson Lab is one of the main priorities identified by NSF’s Nuclear Science Advisory Committee in its 2009 report. This $300M project will require the upgrade of the experimental equipment. In Hall C the existing High Momentum Spectrometer will be paired with a new Super High Momentum Spectrometer (SHMS). The JMU Particle and Nuclear Physics group is in charge of designing, building, and testing the scintillator hodoscope, an essential component of the SHMS. In this presentation we document the assembly of the scintillator detectors to be used by this hodoscope, including early testing of the resistive photomultiplier bases.

10:00 am: Checking Special Relativity Using Cosmogenic Neutrinos
Authors: Jason Brown
Faculty Mentor: Dr. Sean Scully
Cosmic ray proton interactions with the cosmic microwave background (CMB) photons, as they propagate from cosmological distances, leads to the production of three neutrinos per interaction. These neutrinos can potentially be detected here on the Earth by kilometer squared detectors or balloon-borne experiments currently being constructed and operated at the South Pole. Estimating the final energy and numbers of produced neutrinos can provide a check on special relativity. Special relativity is violated by introducing non-invariant terms into the standard model Lagrangian that are assumed to be re-normalizable (dimension >=4), invariant under SU(3)⊗SU(2)⊗U(1) gauge transformations, and rotationally and translationally invariant in a preferred frame. This preferred frame is taken to be the frame of the CMB. The modification manifests itself as an energy dependent increase in the rest mass of the particles involved in the interaction. The constant of proportionality is designated as d. A Mathematica code is developed that takes a cosmic ray proton of a given energy and redshift, and by Monte Carlo determines all interactions as it propagates to Earth. The code constructs an array of initial proton energies and redshifts with the resulting neutrinos and their energies for a given choice of d. This array could then be used to construct a neutrino spectrum that can be tested against future results from the South Pole experiments.

10:15-10:45 am: Coffee Break

10:45 am: Zn and ZnO Nanowires Grown on PEDOT-PSS Thin Films Conductive Polymers by Physical Vapor Deposition
Author: Matthew Chamberlin
Faculty Mentor: Dr. Costel Constantin
Due to the fact that nanowires have a very large surface-to-volume ratio, there is a significant interest in combining them with conductive polymers to improve overall performance. The p-type polymer poly(3,4 ethylenedioxythiophene):poly (stryenesulfonate), also known as PEDOT:PSS, has received particular attention due to
its high conductivity and is commonly used as a hole-injecting material in applications such as solar cells, sensors, and antistatic coatings. In this study, we present results from different growth mechanisms such as i) PEDOT:PSS/Zn-nanowires/quartz, ii) Zn-nanowires /PEDOT: PSS/quartz, and iii) ZnO - nanowires/ gold-nanoparticles /PEDOT:PSS/quartz. All PEDOT:PSS thin films were deposited on 1 cm by 1 cm fused quartz substrates by spin coating in a three step process: 1) 500 rpm for 10 sec, 2) 800 rpm for 10 sec, and 3) 1500 rpm for 60 sec. All the Zn- and ZnO-nanowires were deposited on top of quartz or PEDOT:PSS polymers by physical vapor deposition. The preliminary results show that Zn-nanowires bond better to the non-annealed PEDOT:PSS thin films. It was also found that ZnO-nanowires grow homogeneously on annealed PEDOT:PSS surfaces with gold-nanoparticles as bonding reaction catalysts. Future plans include electrical and optical characterization of the thin films produced using each method.

11:00 am: The Spectral Properties of Galaxies with H2O Maser Emission
Author: Nathan DiDomenico
Faculty Mentor: Dr. Anca Constantin
Mega-masers are remarkable natural phenomena. Mapping of the H2O mega-maser emission has provided the first direct evidence for the existence of a thin Keplerian accretion disk with turbulence in galaxy centers believed to be powered by accretion onto supermassive black holes, highly compelling evidence for the existence of a massive black hole, as well as a cosmic distance determination of extremely high precision. To date, such observations and associated calculations have been performed on only less than a handful such systems. Identifying and studying a large sample of the mega-masers in this particularly rare disk configuration is of crucial importance for our progress with understanding the accretion processes in galaxy centers, and more importantly, for constraining the proposed cosmological models and the nature of dark energy. We present an investigation of the optical spectral properties of a large, statistically significant sample of water maser galaxies together with a control sample of all galaxies ever surveyed in water maser emission. Our analysis shows for the first time that galaxies not associated with black hole accretion are likely to host mega-masers. The results should provide efficient ways in which we should search for new mega-maser disks, in order to find enough of them to constrain the fate of our universe.

11:15 pm: Analysis of $^{181}$Ta($\gamma$, n) Asymmetries
Author: Will Henderson
Faculty Mentor: Dr. Steve Whisnant
Data have been collected at the High Intensity gamma-ray Source (HI $\gamma$ S) to investigate neutron emission from a $^{181}$Ta target with linearly polarized gamma rays at E= 11, 12, 13, 14, and 15.5 MeV. Liquid scintillator detectors were placed at scattering angles of 55 deg, 90 deg and 125 deg above, below and to the left and right of the target. Four additional detectors were placed at angles of 72 deg and 107 deg along the top and right. The E dependence of the ratios of neutron yields, Ipara/Tperp are examined. The ratio at 90deg should depend only on the P2 (cos $\theta$) coefficient in the angular distribution. The comparison of these results will be discussed.
11:30 am: Neutron Photoproduction from Sn with Linearly Polarized $\gamma$ rays between 13 and 15 MeV.
Authors: James Hauver
Faculty Mentor: Dr. Steve Whisnant
Data have been collected at the High Intensity $\gamma$-ray Source (HI $\gamma$ S) to investigate neutron emission from a natural Sn target with linearly polarized gamma rays at $E_{\gamma} = 13, 15, \text{ and } 15.5$ MeV. Liquid scintillator detectors were placed at scattering angles of $55^\circ, 90^\circ \text{ and } 125^\circ$ above, below and to the left and right of the target. Four additional detectors were placed at angles of $72^\circ \text{ and } 107^\circ$ along the top and right. The $I_{\text{para}}$ dependence of the ratios of neutron yields, $T_{\text{perp}}$, are examined. The ratio at $90^\circ$ should depend only on the $P_2(\cos(\theta))$ coefficient in the angular distribution. The comparison of these results will be discussed.

11:45 am: A Formant-Based Synthesizer in Max MSP
Authors: Thomas Redpath
Faculty Mentor: Dr. Butner, Dr. Hall, Dr. Peterson
There are numerous methods for exactly reproducing moment-to-moment variations in frequency, intensity, and phase in order to synthesize natural sounding instrument tones, and with the level of computing power available today, these processes are readily available (Beauchamp 1969, Serra 1989, Horner 2007, Cann 2007). While a complete resynthesis may preserve the naturalness of a musical instrument tone, it is likely that such complexity is not perceptually salient to a listener. Therefore, the amount of information required for resynthesis could be drastically reduced with minimal detriment to a listener’s ability to identify the source instrument if care is taken to preserve perceptually relevant aspects of the tone, like frequency characteristics and duration of the tone’s attack (Grey 1977). Systematically reducing the amount of information present in the resynthesis will allow researchers to investigate the degree of information reduction to which a tone can be subjected and still have its source instrument correctly identified. This project seeks to develop a synthesizer that takes advantage of this potential for information reduction by modeling sound production as a simple waveform source passed to a parallel bank of filters (with user-controllable center frequency and bandwidth parameters) configured to model the resonant structure of the instrument body. This determines the frequency content in a way that is conceptually similar to how the sound is actually produced. An overall amplitude envelope allows for specification of the overall duration, attack and release times. Programming of this synthesizer was carried out in the Max MSP environment. Testing the accuracy of resynthesis requires extracting spectral and intensity data from digital recordings of natural tones and methodically reducing these data to produce numerical input for the synthesizer.
12:00 pm: Exploring X-ray Bright Optically Normal Galaxies

Authors: Anthony Miles
Faculty Mentor: Dr. Anca Constantin

We will present an exotic species of Active Galactic Nuclei (AGN), the X-ray Bright Optically Normal Galaxies (XBONGs). These objects show strong X-ray emissions but do not show strong optical emission-line activity that we would expect from an actively accreting super-massive black hole, or an AGN. The optical spectra of XBONGs bear resemblance to a simple collection of stars, i.e. a normal galaxy. We will review the physics of the AGN emission over the whole electromagnetic spectrum in comparison with that of a normal galaxy, focusing in particular on the relationship between optical and X-ray emissions. There are five different possible explanations for XBONGs, however, the small number of statistics does not allow a thorough investigation of these systems. We will present a new sample of eight sources that has the potential of solving the mystery of the XBONG phenomenon.

12:15 pm: Soft Complex Flow Project

Author: Robert Turner
Faculty Mentor: Dr. Klebert Feitosa

Steady state foams are used for bedding, insulation, and even as a means of mineral separation in mining; however their properties are not totally known because the processes they go through in order to reach an equilibrium state, such as coarsening, are still not fully understood. We built a device that generates a steady state, aqueous foam and can be used to study these equilibrium bound processes. This device is simply called a “Foam Column.” The Foam Column is a clear tube with a gas dispensing needle at its base. Gas is dispersed at a certain rate into the column that is partially filled with a soap solution. This generates steady state foam. Arranged at specific heights along the side of the Foam Column are electrodes. These electrodes allow us to determine the conductivity of foam and solution and subsequently the liquid content at specific heights. The clear tube allows for photo-analysis of its contents to determine things such as bubble speed and volume and foam geometry. The coarsening of foam as a function of height, for example, can be found using the measured properties the Foam Column provides. As well as being a good tool to use in order to study equilibrium bound processes of foams, the Foam Column may be used for future experiments involving dense foams, sedimentation, and bubble flow in a variety of liquids.