

Oregon State University Department of Physics  
SENIOR THESIS PRESENTATIONS  
Part I: Monday, June 11, 2012  
WENIGER 304  
Refreshments will be served!

STUDENTS are especially welcome!

**1:00 – 1:15 Jaryd Ulbricht**

Design and Implementation of Apparatus to Create Calibration Curves for use in Laser Induced Fluorescence Experiments

Advised by Vinod Narayanan, OSU MIME

**1:15 – 1:30 Marcus Cappiello**

Effects on the Corpus Callosum of Ferrets Due to Restriction of Visual Input During the Prenatal Stage and Optimization of Diffusion Tensor Imaging Protocol

Advised by Christopher Kroenke, OHSU

**1:30 – 1:45 Shawn Gilliam**

Use of a Digital Micromirror Array as a Configurable Mask in Optical Astronomy

Advised by William Hetherington

**1:45 – 2:00 Jake Goodwin**

The Pressure Transmission Through an Air-filled Rubber Shell

Advised by Brian Bay, OSU MIME

**2:00 – 2:15 Jonathon Greene**

Effects of Van der Waals Interactions on Surface Polarization Reflection

Advised by William Hetherington

**2:15 – 2:35 Nick Petersen & Brian Devlin**

Measuring Neutron Absorption Cross Sections and Epithermal Resonance Integrals of Mercury and Platinum via Neutron Activation Analysis

Advised by Kenneth Krane

**2:35 – 2:45 Mason Keck**

Analysis of X-Ray Emission in Neutron Activation Analysis

Advised by Kenneth Krane

Oregon State University Department of Physics  
SENIOR THESIS PRESENTATIONS  
Part II: Tuesday, June 12, 2012  
WENIGER 304  
Refreshments will be served!

STUDENTS are especially welcome!

**9:30 – 9:45 Colby Whitaker**

Noise reduction of OSU's radio telescope

*Advised by William Hetherington*

**9:45 – 10:00 Billy Geerhart**

Melting Curve of a Lennard-Jones 12-6 System Determined by Coexistence Point Simulations

*Advised by Guenter Schneider*

**10:00 – 10:15 Christopher Jones**

Discrete time quantum walk with two-step memory

*Advised by Yevgeniy Kovchegov, OSU Math and Zlatko Dimkovic*

**10:15 – 10:30 Murray Wade**

Creating a Thermodynamics Simulation Using the Ising Model: A Microcanonical Monte Carlo Approach

*Advised by David Roundy*

**10:30 – 10:50 Timothy Mathews & Tyler Turner**

Developing Techniques to Measure Single Molecule Conductance: Design Considerations, Complications, and Instrumentation

*Advised by William Hetherington*

---

Earlier thesis presentations by the class of 2012

**Teal Pershing** Solar Granulation Imaging Techniques Using Optical Fourier Analysis *Advised by William Hetherington*

**Sam Settlemeier** (Honors College) Student Motivation, Introductory Calculus Based Physics (PH 211) and Project Based Learning, Oh my!

*Advised by Dedra Demaree*

**Mason Keck** (Honors College) X-ray Spectroscopy in Astrophysics and Neutron Capture Cross Section Measurements

*Advised by Kenneth Krane*

Future thesis presentations by the class of 2012

**James Montgomery**

TBA

*Advised by William Hetherington*

---

Abstracts and Biographies:

**Marcus Cappiello**

*Effects on the Corpus Callosum of Ferrets Due to Restriction of Visual Input During the Prenatal Stage and Optimization of Diffusion Tensor Imaging Protocol*

A new magnetic resonance imaging technique called diffusion tensor imaging was used to image the diffusion of molecules within the corpus callosum of ferret brains. This bundle of axons is involved in the control of motor, auditory, and visual systems. The effect of visual input impairment on the corpus callosum was explored in the developmental stages of the ferrets using diffusion tensor imaging while concurrently exploring new diffusion tensor imaging protocol for maximum precision. No changes in the size of the corpus callosum were observed due to bilateral retinal enucleation (bi-enucleation) in the developmental stage of the ferrets using diffusion tensor imaging. To explore an optimum protocol, three different diffusion weighting strengths (b-values) ranging from 2.5 ms/mm<sup>2</sup> to 7.5ms/mm<sup>2</sup>, and two echo time values of 42ms and 63.5ms were tested on the samples pairs of corpus callosums consisting of one bi-enucleated and one control. In general, the fractional anisotropy is found to increase with increased b-value, with a b-value of 7.5 ms/mm<sup>2</sup> yielding the highest. This may not indicate higher precision due to a decrease in the signal to noise ratio. Scans with a b-value of 2.5 ms/mm<sup>2</sup> and an echo time of 42ms were chosen for further analysis. All samples have been sent to the University of Washington for electron microscopy measurements of axons for comparison.

**Bio:** Marcus Cappiello got his high school diploma in 2008 from Los Alamos High School in Los Alamos, NM. He is in his fourth year in Biophysics at Oregon State University and held an internship at Oregon Health and Sciences University (OHSU) in the summer of 2011. He will be returning to OHSU this coming summer to participate in an undergraduate research fellowship. His senior thesis was conducted under Dr. Kroenke in the Advanced Imaging Research Center at OHSU. He plans to get his PhD in neuroscience after graduating from Oregon State University.

**Billy Geerhart**

*Melting Curve of a Lennard-Jones 12-6 System Determined by Coexistence Point Simulations*

This project calculates the melting temperature as a function of pressure for a system defined by the Lennard-Jones 12-6 potential using molecular dynamic simulations. In a single atomistic simulation, the initial conditions are manipulated such that both a liquid and solid phase exist when thermal equilibrium is reached. Phase coexistence indicates that these simulations must be at the melting point, which means the average pressure and temperature provides a data point for the coexistence line between the liquid and solid phase. For this project, over 100 coexistence point simulations were created, and the interpolation of the average pressure and temperature from these simulations agree to within 1% of literature values that were obtained with a number of different simulation techniques.

**Bio:** Born in Alaska, my first memory was crossing the slough in a kayak to get to fish camp. In the first grade, I was told to draw what I wanted to be when I grew up; I drew myself as a scientist making inventions. Later on in life, I remember my high school physics teacher asking me to define physics; at the time, I thought physics was about trying to define reality. In other words, I thought physics was about finding out what actually happens. I found myself bored with anything not related to math, so I dropped out of high school when I was 16 so that I could take math courses at Chemeketa Community College. Once Chemeketa could teach me no more math, I found myself at Oregon State University as an undergrad in physics. In my first year at OSU I pushed myself to make up for dropping out of high school, but my performance dropped as the years went by. I eventually found myself in my senior year needing only classes which I hated, so again I questioned whether or not I really wanted to finish my education. I ultimately decided that my current path was not for me, so I spent the next four years as a truck driver while I tried to find a direction for my life. I remember thinking deeply one night when I realized that physics was not about trying to capture the essence of reality; instead, physics was about trying to find anything that works to describe our universe. While thinking these strange thoughts, I started to question the basic assumptions in physics. As someone who questions the foundations of physics, my current goal in life is to show how dark matter can be explained without having to use a dark

matter particle. As a first step towards my goal, I have finished my undergraduate education in physics. The next step towards my goal will be to learn enough math to explore dark matter using general relativity.

### **Shawn Gilliam**

#### *Use of a Digital Micromirror Array as a Configurable Mask in Optical Astronomy*

High resolution images of a dim companion in a binary star system can be obtained using a Digital Micromirror Array (DMA) as an aperture mask. Imaging can be problematic because the intense light from the main star can saturate the detector and leave the companion unnoticed. Placement of the DMA in the image plane allows for the replication of widely-used aperture masking techniques such as a coronagraph. A laboratory model of a binary star system with a bright source that is 28000 times brighter than the dim companion is resolved at 20.63 arcseconds. Another simulation uses the pixels of a monitor to acquire an angular resolution of 3.43 arc seconds. Stop-down masks and speckle interferometry masks will also be discussed.

**Bio:** Shawn Gilliam was born in Lebanon, Oregon. He attended high school there and Linn-Benton Community College in Albany, Oregon afterward. In 2003, he joined the Army. He met and married Leleiga Seiuli, in 2005. They now have three children, daughters Meliana and Ciara, and a son, Selatoa. When he and his family returned to Oregon after his service, he went back to LBCC, and then to Oregon State University to pursue a degree in Physics. His research is titled "Use of a Digital Micromirror Array as a Configurable Mask in Optical Astronomy", advised by Dr. William Hetherington. Beginning June 19<sup>th</sup> he will be attending the University of Oregon in the Master's Industrial Internship Program.

### **Jake Goodwin**

#### *The Pressure Transmission Through an Air-filled Rubber Shell*

In order to simulate and better understand a modern method for testing compression garment pressure an apparatus was built to apply external pressure to the surface of a rubber shell while simultaneously measuring the internal pressure resulting from the shell's deformation. The data was then used as input to Hertzian contact equations in order to see if the results could be easily predicted with the analytical theory. The measured internal pressures varied from 43.1 to 517 Pa whereas the calculated pressure values varied from 183 to 805 Pa with the calculated values, on average, 2.07 times the measured values. Also, the measured pressure values vary from the surface pressure by an average of 0.6%, whereas the calculated pressure values vary by an average of 0.4% from the surface pressure. Therefore, it is suggested that the pressure transmission is within 99%.

**Bio:** Jake, 26 years old, was born in Eugene, Oregon and raised in Creswell, Oregon. He completed a two year degree at Lane Community College before transferring to OSU in 2009. At OSU he has completed a dual degree program in Engineering Physics (mechanical focus) and Applied Physics. Throughout his college years he has been a math tutor, a physics TA, a wildland firefighter and a park ranger. Also, he enjoys riding motorcycles, home brewing and climbing trees.

### **Jon Greene**

#### *Effects of Van der Waals Interactions on Surface Polarization Reflection*

Intensity beam profiles of a 633 nm laser off a super-polished glass surface were captured using surface polarization reflection. Profile capture can be difficult due to the relative intensities of molecular reflection versus macro reflection. Surface polarization reflection uses parallel-polarized light incident at Brewster's angle to extinguish macro reflection. A jet of weakly interacting gas is focused on the super-polished glass, the profile is captured, and the control intensity profile is subtracted to deduce the effects of Van der Waals interactions on surface polarization reflection. The optical arrangement uses a 25 micron spatial filter, a crystal polarizer, and a 375 x 242 pixel SBIG CCD camera. Thermal stabilization of the laser diode as well as data acquisition and processing will be discussed.

**Bio:** Jon Greene graduated from West Salem High School in 2007 and is graduating with a Bachelor of Science in Physics from Oregon State University Spring term 2012. His senior thesis research was

## Oregon State University Department of Physics

advised by Dr. William Hetherington. He is taking a year off to study for the GRE Physics subject test and will pursue graduate school next year

### **Christopher Jones**

#### *Discrete time quantum walk with two-step memory*

We examine a discrete time quantum walk with two-step memory for a particle on a one-dimensional infinite space. The walk is defined with a four-state memory space analogous to the two-state coin space commonly used in discrete time quantum walks, and a method is presented for calculating the time evolution by using the Fourier transform. The generating function for the probability is determined and then used to produce numerical solutions for the probability distribution as a function of the time step and position. The results show two peaks in the probability distribution. One peak propagates linearly with time, which is a common feature of quantum walks. The other peak is stationary with time and located at the initial site of the particle. This feature is not common in quantum walks and suggests that tracing the immediate history of the particle using two-step memory may represent the beginning of a transition to a classical system.

**Bio.** Christopher Jones graduated from Red Bluff High School in Red Bluff, California in 2008. He began attending Oregon State University in 2008 to enter the Physics program and minor in Mathematics. His senior thesis research advisor was Professor Yevgeniy Kovchegov from the OSU Department of Mathematics, and the work was also completed under the guidance of Zlatko Dimcovic from the Department of Physics. After graduating, Chris plans to return to OSU next year to enter the graduate program. He will be working as a teaching assistant in the Physics Department while pursuing a M.S. degree in Physics.

### **Mason Keck**

#### *X-ray Spectroscopy in Astrophysics and Neutron Capture Cross Section Measurements*

X-ray spectroscopy was carried out for separate projects at NASA Goddard Space Flight Center and Oregon State University. A computational routine, 'Drive XSPEC', was developed to help determine the feasibility of pursuing various science goals with future X-ray calorimeter spectrometer missions, most significantly the NASA Advanced X-ray Spectroscopy Imaging Observatory (AXSIO) mission concept. 'Drive XSPEC' can run spectroscopic simulations with various physical models and telescope designs. 'Drive XSPEC' can be applied to developing proposals for telescope time.

At OSU, X-ray emissions in neutron capture spectra of the production of  $^{197}\text{Hg}$  and  $^{197}\text{Pt}$  near 77 keV were analyzed to determine the thermal cross section and resonance integral for the production of  $^{197}\text{Hg}$  and  $^{197}\text{Pt}$ . Through correcting for X-ray emissions, peak intensities from the 77.3 keV gamma ray produced in beta decay of  $^{197}\text{Hg}$  and  $^{197}\text{Pt}$  were analyzed. From this analysis, thermal cross section and resonance integral values were determined to be  $448 \pm 27$  and  $2088 \pm 133$  for the production of  $^{197}\text{Hg}$ , and thermal cross section and resonance integral values were determined to be  $6.72 \pm 0.51$ , and  $0.615 \pm 0.054$  for the production of  $^{197}\text{Pt}$ . These values agree with those found from the analysis of the 191 keV gamma ray produced in in beta decay of  $^{197}\text{Hg}$  and  $^{197}\text{Pt}$ .

**Bio:** Mason grew up in Florence and Canyonville, Oregon, and graduated from Siuslaw High School in Florence, Oregon. Mason's parents are Linda Keck, who worked in K-12 education, and Gerald Keck, who works as a forester. Mason will be graduating from OSU this spring and entering the Boston University Astronomy Graduate Program in the fall. Mason also worked on the Radio Telescope Project at OSU. Mason played on the Ultimate (Frisbee) Club Team at OSU for two years and was a member of the Society of Physics Students for two years. Mason also enjoys playing guitar. Mason enjoyed track and field in high school.

### **Timothy Mathews &**

### **Tyler Turner**

#### *Developing Techniques to Measure Single Molecule Conductance: Design Considerations, Complications, and Instrumentation*

This project developed techniques and methods to measure single molecule conductance. Break gap

## Oregon State University Department of Physics

junctions, used to measure electrical properties of single molecules, were explored. A Hewlett Packard mechanical nano-press was determined to be insufficient for creating a stable gap in which to conduct experiments. To avoid electromigration and bond annihilation across the break gap junction, a two-stage, high-speed, low-noise transimpedance amplifier was built. The two-stage amplification was determined necessary to overcome a tradeoff between high-gain/low-speed and low-gain/high-speed features of operational amplifiers (op amp). The op amp used was a Texas Instruments OPA657 on a printed circuit board designed specifically for the op amp. For proper circuit analysis, a model circuit that demonstrated tunneling, but did not depend on the break gap system was analyzed. With further refinement of the techniques and methods developed in this paper future measurements of single molecules within break gap junctions will be achievable.

**Bio: Timothy Mathews** was born and raised in Fairbanks, Alaska. He was active in the community since joining Cub scouts in 1<sup>st</sup> grade. He attained Eagle Scout at age 14, and in high school he was active in student council and was team captain for the West Valley High school's FIRST Robotics team. After high school graduation in 2005, Timothy attended University of Alaska Fairbanks where he attained an Associate of Applied Science in Information Technology with an emphasis in Networking. He then took it upon himself to attend Oregon State University, where he will be graduating with a Bachelors of Science in Physics and a Minor in Mathematics, at the end of Summer Term 2012. He hopes to continue on in higher education and is currently applying to Geophysics Masters programs around the nation.

**Bio: My name is Tyler Turner** I was born and raised in Albany Oregon. I graduated from South Albany High School in 2008 and started college fall term of 2008 here at Oregon State University. After I graduate this spring with my bachelors' degree in physics with a minor in mathematics, I will be attending the University of Oregon pursuing a Masters in Applied Physics. My research advisor while at Oregon State was Dr. Hetherington.

### **Teal Pershing**

#### *Solar Granulation Imaging Techniques Using Optical Fourier Analysis*

We detail a method to investigate physical correlations between granules, mesogranules, and supergranules produced by convection cells in the sun's photosphere using optical Fourier analysis. An experimental approach to Fourier analysis using a Digital Micromirror Device (DMD) as a spatial filter is developed through the analysis of a Ronchi ruling optical pattern. Maximum intensities measured in the Fourier transform plane with a CCD camera are compared to the theoretical intensities predicted by Fourier optics theory. The shape of the experimental intensity curve generally matches the theoretical curve, except intensity maxima located at  $756 \mu\text{m}$  and  $2268 \mu\text{m}$  from the zero frequency component are about two times larger than the predicted theoretical intensities. Nonzero intensities emerge at  $1512 \mu\text{m}$  and  $3024 \mu\text{m}$  from the zero frequency component, positions at which Fourier theory predicts zero intensity.

Computational Fourier analyses of several Ronchi rulings are performed using the Meade LX200 reflector telescope, Python's "fft" library, and a CCD camera. Resolution of mesogranulation and supergranulation object distance to object wavelength ratios is recognized, and a maximum object ratio of 72,172 is resolved. Detection of a subtle spatial periodicity with object ratio 5027 within a dominant spatial periodicity of object ratio 20107 is detailed.

### **Nick Petersen**

#### *Measuring Neutron Absorption Cross Sections and Epithermal Resonance Integrals of Platinum via Neutron Activation Analysis*

This thesis presents a measurement of the resonance integral and thermal cross section – which together represent the total neutron absorption cross section – of the naturally occurring isotopes of platinum that emit gamma radiation upon neutron absorption. The measurements were made via neutron activation analysis. Platinum samples were bombarded by neutrons produced in Oregon State University's TRIGA nuclear reactor. Afterwards, the decay of the excited samples was measured to determine the activity of each isotope, yielding measurements of the cross sections for each. This experiment was repeated multiple times in different reactor locations to improve accuracy.

## Oregon State University Department of Physics

Previous measurements of these values have been flawed by poor photon detector resolution, and evolving branching ratios, half-lives, natural abundances. A search of the literature reveals poor agreement and large error estimations.

The results from this thesis are consistent, with one exception: there appears to be a systematic disagreement between the resonance integral measurements of samples bombarded in two different reactor locations. This discrepancy has now been seen in several experiments, which indicates inconsistent epithermal flux throughout OSU's reactor.

**Bio:** Nick Petersen grew up and attended High School in Bend, Oregon. He originally came to OSU in 2007 to become an engineer, but then realized he was more interested in Physics. He studied both and will be graduating with a double degree in Physics and in Engineering Physics with a focus in Nuclear Engineering. He has accepted a full-ride assistantship award to study Medical Physics at Louisiana State University in Baton Rouge, LA. The M.S. program lasts three years with the option of taking a residency position afterwards.

### **Sam Settelmeyer:** Student Motivation, Introductory Calculus Based Physics (PH 211) and Project Based Learning, Oh my!

Using research on student motivation as well as Project-Based Learning as a theoretical framework, this thesis outlines the creation process for a set of curricula. These curricula were designed to address topics of markedly low student motivation in the first term of an introductory physics with calculus course (PH 211) at Oregon State University. This process began with the creation and distribution of multiple surveys. The formal validation process as well as non-parametric statistical analysis of these surveys is outlined. These surveys were used to identify "Vectors and Vector Mathematics" as well as "Coordinate System Choices" as topics of particularly low student motivation. Through an iterative process of collaboration and refinement, carbon nanotubes were selected as the platform for these activities. Six 30-60 minute activities were presented in Studio of PH 211 during spring term 2012. A combination of Professor Dedra Demaree's in-class observations and my own reflections on the creation process of these activities are presented. Student feedback will also be collected and included in future research.

**Bio:** Sam Settelmeyer completed his thesis work as well as other research in Professor Dedra Demaree's Physics Education Research Group. He will complete his Physics Degree with an education option and math minor next spring. Sam will also graduate with a Bachelor of Arts from the University Honors College. After a term off, Sam will begin his graduate work in the Science and Math Education Teacher Certification Program here at Oregon State.

### **Jaryd Ulbricht**

#### *Design and Implementation of Apparatus to Create Calibration Curves for use in Laser Induced Fluorescence Experiments*

An apparatus and method for calibrating planar laser-induced fluorescence using a two-dye, two-color method was developed. A laser sheet was expanded from a 473 nm laser to excite dye solutions into higher energy states then fluoresced through spontaneous emission. The two fluorescent dyes selected for research and development were the primarily green emitting 2'7' dichlorofluorescein and the primarily red emitting sulforhodamine B. Planar laser induced fluorescence is used in thermal-fluids experiments as an accurate, non-invasive method for developing flow thermographs used to characterize the performance of experimental devices and methods. Two-color, two-dye methods are used because of their high accuracy, and potentially higher sensitivity relative to other thermography techniques because the temperature can be expressed as a function of only the fluorescence ratio of the two dyes and is independent of local laser intensity, which may vary considerably with time and space during an experiment. Calibration curves and relationships were developed that accurately correlated the local temperature of the solution to the intensity ratio of the dyes. Using a concentration of 2'7'Dichlorofluorescein of  $4.624 \pm 0.294 \times 10^{-6}$  M and a concentration of Sulforhodamine B of  $8.105 \pm 0.294 \times 10^{-6}$  M predicted temperature measurements had an uncertainty of 2.09 °C.

**Bio:** Graduated from McMinnville High School in 2007, receiving the Kiwanis Outstanding Physics Student Award. Attended Oregon State University as a Pre-Mechanical Engineering student for two

## Oregon State University Department of Physics

years then switched to Engineering Physics in 2010. Finished graduation requirements for Engineering Physics in winter 2012 and is currently finishing requirements for a degree in Applied Physics. Worked in Dr. Vinod Narayanan's Thermodynamics and Fluid Mechanics laboratory designing and implementing a method of Laser Induced Fluorescence calibration. Completed a thesis using the research from Dr. Narayanan's lab in the Spring of 2012.

### **Murray Wade**

#### *Creating a Thermodynamics Simulation Using the Ising Model: A Microcanonical Monte Carlo Approach*

The Ising model was used to create a thermal physics simulation of a ferromagnet in thermal contact with a paramagnet. We used a microcanonical Monte Carlo approach with Python and allowed the system to reach or get close to thermal equilibrium. The purpose was to test Dr. David Roundy's lab course curriculum for future students and give an overview of important concepts and processes. 20 simulations of different fixed energies gave us results in the form of magnetization vs. temperature and energy vs. temperature graphs which enabled us to find an approximate Curie temperature for our system. Using a low energy initial state instead of a high energy initial state was found to produce more stable results. Internal snapshots of our ferromagnet in low to moderate temperature states showed groupings of similar spins whereas higher energy states appeared more random. Temperature vs. energy showed a slope close to infinite at the Curie temperature and if statistical noise was factored in, a phase transition could have been within the error. Error was too difficult to factor in late in the experiment, and it is recommended that future students make sure to account for statistical error earlier in the experiment.

*Bio.* Murray Wade graduated from South Salem High School in Salem, Oregon in 2006. His senior thesis research was conducted under the guidance of Prof. David Roundy. He is planning to apply for a job with Intel shortly after graduation.

### **Colby Whitaker**

#### *Noise reduction of OSU's radio telescope*

The radio telescope at Oregon State University presently has a low signal to noise ratio resulting in decreased sensitivity and thus reduced usability of the radio telescope. The noise level must be decreased since the signal power cannot be increased as easily. Noise reduction was accomplished through two methods the first was to obtain a low noise amplifier. The second method was to cool the amplifier down to a significantly lower temperature. Decreasing the temperature from 290 k to 80 k was accomplished using liquid nitrogen allowing for a theoretical reduction in thermal noise by 3 dB.

*Bio.* Colby Whitaker will graduate spring 2013 from Oregon State University with a double degree in Applied Physics and Electrical & Computer Engineering. After which he will enter the Master's Industrial Internship Program at University of Oregon for photovoltaic and semiconductor device processing. His senior thesis was reducing noise in Oregon State University's radio telescope under Dr. Hetherington. Involvement in extracurricular activities includes having served as the Judicial council chair of the Associated Students of Oregon State University for one year and as a Councilor for 2 years.