Oregon State University Department of Physics

SENIOR THESIS PRESENTATIONS
Part I: Tuesday, June 2, 2015
WENIGER 304
Refreshments will be served!
STUDENTS are especially welcome!

3:00 – 3:10
Joshua Mutch: Temperature Dependence of Cu3-xSb1-yMyS4 (M=Sn,Ge) Resistivity and Thermopower

Advised by Janet Tate

3:12 – 3:22
Bao Nguyen: Computational Modeling of Photon Scattering In Gamma Ray Bursts Using Monte Carlo Techniques

Advised by Davide Lazzati

3:24 – 3:34
Scott Hutchings: Observing the third harmonic sinusoidal voltage response of a small incandescent lightbulb

Advised by Janet Tate

3:36 – 3:46
Mitchell Senger: Framework for Computational Modelling of Cellular Diffusion Systems

Advised by Bo Sun

3:48 – 3:58
Joshua Montegna: Determining the Effective Entropy of a Fractal Visual Hash System

Advised by David Roundy

4:00 – 4:10
Dan Lin: A Novel Method for Detecting Lines on a Noisy Image

Advised by Bo Sun

4:12 – 4:22
Samuel McLain: Leapfrog Integration as an Accurate and Uncomplicated Alternative for N-Body Simulations in Computational Astronomy

Advised by Tom Giebultowicz

4:24 – 4:34
Dalton McCuen: Complex Index of Refraction of Multi-walled Carbon Nanotubes in Strong Terahertz Fields.

Advised by Yun-Shik Lee

4:36 – 4:46
Blake Wells: Bandgap measurements of nonspecular materials using a bifurcated fiber optic method of diffuse reflectance
Advised by David McIntyre

4:48 – 4:58
Connor O’Driscoll: Hyperspectral Fluorescence and 2-Photon Surface Imaging of “Graphene-like” Dichalcogenides

Advised by Matt Graham

version 2 June 2015

SENIOR THESIS PRESENTATIONS
Part II: Monday, June 8, 2015
WENIGER 304
Refreshments will be served!
STUDENTS are especially welcome!

3:00 – 3:10
David Konyndyk: Design of an Optical Medium for the Simulation of Neutron Transport in Reactor Component Materials
Advised by Klein

3:12 – 3:22
Lisa Fletcher: Nucleation of Iron Dust from Type II Supernovae
Advised by Davide Lazzati

3:24 – 3:34
Alex Poff: Hall Effect in Semiconducting Thin Films
Advised by Janet Tate

3:36 – 3:46
Samuel Stephenson: Hyperspectral Absorption and Fluorescence Surface Imaging Microscope
Advised by Matt Graham

3:48 – 3:58
Blythe Nourie: Computational Analysis of Spin Systems in Lattice Using the Heisenberg Model
Advised by Henri Jansen

4:00 – 4:10
Cameron Thayer-Freeman: Comparison of a Persistent Random Walk to MDA-MB-231 Cancer Cell Chemo taxis through a 2.5D Collagen Matrix
Advised by Bo Sun

4:12 – 4:22
David Delaney: A Study of the Graphite-Diamond Energy Groundstates and the Phase Transition Pressure Using Density Functional Theory
Advised by David Roundy

4:24 – 4:34
Patrick Kreitzberg: Monte carlo simulations for a soft sphere fluid
Advised by David Roundy

4:36 – 4:46
Abigail Merkel: Designing and Implementing a Portable Interface System for Field-Effect Transistor Biosensors
Advised by Ethan Minot

4:48 – 4:58
Seamus O'Callaghan: Single Molecule Studies of the Bidirectional Movement of Yeast Kinesin-5/Cin8
Advised by Weihong Qiu

Earlier thesis presentations by the class of 2015

L Bonner (Honors College): A magnetotelluric investigation of shallow conductivity sources beneath the Cascadia Volcanic Arc
Advised by Adam Schultz
Jacob Busche (Honors College): Optical Tweezers-Based Probe of Charge Transfer in Organic Semiconductors at Microscopic Scales
Advised by Oksana Ostroverkhova

Michael Perlin (Honors College): Optimizing Monte Carlo Simulations of the Square-Well Fluid
Advised by David Roundy
Austin Valeske (Honor College): Determining Free Energies of Hard Sphere Fluids via Monte Carlo Simulation
Advised by David Roundy

Abstracts and Biographies:

L Bonner (Honors College)**:** A magnetotelluric investigation of shallow conductivity sources beneath the Cascadia Volcanic Arc

The Cascade Volcanic Arc has been the subject of extensive study in the past due to its active volcanism and its proximity to metropolitan areas. The triangle formed by the volcanoes Mount Saint Helens, Mount Rainier, and Mount Adams is of particular interest because of this potential danger and the geological complexity of the area. Anomalously high conductivity, known as the Southern Washington Cascades Conductor (SWCC), was detected in portions of the region and attributed to trapped marine sediment and partial melt from volcanism in different studies. The magnetotelluric method was used to study the shape and potential causes of the SWCC through acquiring surface electric and magnetic field data throughout the region in 2014, as part of the NSF funded iMUSH project. A linear northeast-to-southwest profile of stations was analyzed to produce a two-dimensional conductivity cross-section through inversion. The best fitting conductivity model was checked with the preexisting studies and found to confirm the existence of the SWCC in certain areas. The model also showed signs of marine sediment and volcanism presence in different portions of the region, though geological complexity and data set limitations prevented a definitive conclusion from being drawn.

Bio: L grew up in Beaverton, OR and graduated from Aloha High School in 2011. He decided to pursue his lifelong academic passions by majoring in physics, with a mathematics minor and a geophysics option. L will graduate with an H.B.S this spring 2015, and he plans to enter the OSU graduate Ocean, Earth, and Atmospheric Sciences program with a concentration in geophysics this fall. His hobbies include video games, tennis, and hiking.

Jacob Busche (Honors College)**:** Optical Tweezers-Based Probe of Charge Transfer in Organic Semiconductors at Microscopic Scales

I present a technique to study the (dis)charging of organic semiconductor films at microscopic scales, and in various environments, using an optical tweezers-based method combined with fluorescence spectroscopy. The 1 μm silica spheres were coated with either pristine organic semiconductor or a donor-acceptor blend, trapped using optical tweezers, and their fluorescence was measured concurrently with the effective surface charge. The effective surface charge in uncoated silica spheres suspended in water was a factor of ~70 higher as compared to that from similar spheres in a nonpolar toluene. In contrast, the coated silica spheres exhibited low effective charge densities in both environments, which is indicative of minimal interaction of organic semiconductors under study with these environments. This serves as a proof-of-principle experiment towards systematic studies of nanoscale photoinduced charge-based interactions between organic semiconductor molecules, with a resolution down to an elementary charge, and depending on the dielectric environment.

Bio: : Jacob grew up in Boise, ID, attending high school at Borah High School. He decided to major in physics to indulge his curiosities about the surrounding universe. Jacob will graduate with a B.S. in physics in Spring 2015 with a minor in mathematics. He will attend graduate school at the University of Washington in the fall of 2015. Jacob spends his free time playing jazz piano, which he also participates in as a member of the OSU Jazz Ensemble, running, climbing, writing, and thinking.

David Delaney: A Study of the Graphite-Diamond Energy Groundstates and the Phase Transition Pressure Using Density Functional Theory

In the present paper, the pressure phase transition pressure between graphite and diamond is explored. With computational software packages VASP and Gem, the crystalline compositions of different structures of Carbon are investigated using density functional theory (DTF). The two primary structural formations of the element Carbon are graphite and diamond. While both have various industrial applications, diamond is of much greater value due to its natural rarity. The groundstates of the two substances are found experimentally through the Kohn-Sham method, provided by VASP, as total energy per atom versus the volume per atom. With thermodynamics, the aforementioned information is used to calculate the enthalpy of each system at their groundstates. The enthalpy between the two groundstates can be interpreted as a change in pressure. This value is called the phase transition pressure and displays the required pressure per atom to transfer between the states of graphite and diamond

Bio: David Delaney grew up in Portland Oregon where he graduated from Wilson High School in 2010. Graduating from Oregon State University this term, he plans to find work in industry to gain experience and perspective before returning to school for a graduate degree in the future.

Lisa Fletcher: Nucleation of Iron Dust from Type II Supernovae

When a star dies in a supernova, its constituent particles are torn apart and a gaseous cloud of atoms remains. These atoms may eventually condense again into large bodies such as planets and stars. There are three main theories as to how this happens: classical, kinetic, and non-local thermodynamic equilibrium (non-LTE). In the classical theory, no nucleation can occur below a critical density and saturation and does not account for much of the nucleation that must occur in the interstellar medium (ISM). The kinetic and non-LTE theories allow for nucleation to occur below the classical critical levels. Most research into this area so far has been focused on the formation of carbon dust. Carbon has a very specific geometry and behaves rather uniquely from a chemical perspective. I was curious as to how a difference in atomic geometry and chemical behavior would affect the formation of dust particles. To investigate this, I am studying the formation of iron dust in supernova remnants. The assumptions that the iron in the supernova remnants exists solely as individual atoms, that the iron atoms are spherical, and that cloud is composed solely of iron atoms all simplified the initial results. Once reasonable results are obtained with these assumptions, they may be removed in order to get a more realistic picture of the formation of iron dust.

Bio:

Scott Hutchings: Observing the third harmonic sinusoidal voltage response of a small incandescent lightbulb

The third harmonic voltage, or 3 omega (3ω) voltage, arises from applying a 1ω sinusoidal voltage across a resistive material. The 3ω voltage carries with it information about the thermal conductivity of the material. A lock-in-amplifier is used to analyze and measure the 3ω voltage; the abilities of the lock-in amplifier are explored using an RLC series circuit. Our initial findings show the lock-in amplifier is able measure the 3ω signal without needing to subtract out the larger first harmonic voltage, the 1ω signal.
Bio: Scott Hutchings grew up in Eugene, OR. After high school he started taking classes at community college. This is where he found his interest for science and physics in particular. After graduating he

chose to go to OSU where he will graduate with a B.S in physics. He hopes to take a break from school and work for a year or two before attending grad school.

David Konyndyk: Design of an Optical Medium for the Simulation of Neutron Transport in Reactor Component Materials

The diffusion of optical rays by small spherical particles bears a strong resemblance to the scattering of fission neutrons in solid materials. This work explores the feasibility of exploiting similarities between the two systems for the purposes of reactor component analysis, education, and outreach. After a brief analysis of reactor-environment neutronics, an easily-producible optical scattering medium is proposed and examined for its ability to faithfully simulate scattered neutron distributions and energy deposition patterns. Individual scattering particles (3M Spherical Glass Microshells) are probed for their ray-scattering properties, and a random-walk simulation reveals how an iterated scattering process could be used to mimic theoretical scattering angle probability distributions for given materials. Iterative angular probability distributions in the optical system are shown to evolve in similar fashion to neutron scattering angle distributions with respect to atomic mass number, and further quantitative relationships are established between the disparate systems. Stopping short of a final optical test for correlation with accepted benchmark simulations, thorough groundwork is laid for future experiments. Methods and materials are discussed in detail, and possible end-use applications are considered.

Bio: David hails from northern Michigan. He has traveled the western states as an outdoor enthusiast, wildland firefighter, and commercial fisherman. His interest in physics began at an early age, and grew while reading books during the night shift in his job at an Oregon ski resort. David spent six years in aviation manufacturing and engineering and enjoys applying his hands-on experience with design, machining, and fabrication. His formal education included a two-year earth science internship in the study of paleomagnetism, wherein he designed and built automated test equipment. He also attended a summer internship with NASA that involved the design and testing of space-based nuclear-thermal reactor components. David plans to continue his education with a Master's degree, and has interests in nuclear and particle physics. In his free time, David enjoys snowboarding, running, fishing, camping, and high-voltage electronics.

Patrick Kreitzberg: Monte Carlo simulations for a soft sphere fluid

In this paper I present the results of Monte Carlo simulations for a soft sphere fluid with a Weeks-Chandler-Anderson pair potential. The results are compared to Soft Fundamental Measure Theory results obtained by Dr. Roundy at Oregon State University. Others have developed a SFMT but did not apply it to many different situations, our goal was to show that our SFMT is very robust.

I was able to confirm Dr. Roundy's results for the pressure of a homogeneous soft sphere fluid at different reduced densities, including the transformation from a fluid to a soft sphere solid. Experimental data for the radial distribution function of an Argon was, in some cases, predicted very well using a soft-sphere fluid surrounding a sphere that has a Leonard-Jones pair potential.

Bio: Pat grew up in Salem, OR where he graduated from Sprague High School in 2007. He started out in electrical and computer engineering at Oregon State. After a year he switched into physics and another year later decided to double major with math and physics. After taking two years off of school he completed the requirements for his B.S. in math in spring 2014 and is on track to graduate with both degrees in spring 2015. He hopes to go to return to school soon and earn his Ph.D. in mathematics.

Daniel Lin: A Novel Method for Detecting Lines on a Noisy Image

We developed an integration-based line detection algorithm. Existing line detection methods such as the Hough Transformation (HT) and its variants are insensitive to image noise. The reason is that HT _nds lines by calculating the gradient of the image and assumes that the region where the gradient is the steepest is where lines exist. This is problematic because if an image has an extremely noisy region, then HT can produce false positive results. Using _lters to remove noise on images can increase computational complexity. There are existing line detection algorithms based on template matching that are robust against noise. However, those algorithms are complex and hard to implement. Our method identifies lines by calculating the correlation score between a set of template line images and the raw image. We calculate the correlation score by multiplying each pixel between the template line image and the raw image and summing their product, or integrating each pixel on the raw image. Our algorithm is simple to implement and requires no application of noise filters onto a noisy image. Additionally, our algorithm removes the necessity for users to use segmentation techniques such as Canny edge detection. We were able to use our algorithm to extract collagen fibers from a noisy image produced by a confocal microscope.

Bio: Daniel Lin is a student studying Computer Science and Physics at Oregon State University. His interests in Computer Science are Cryptography, Image Processing, and Parallel Programming. If Daniel is not doing Computer Science, he can be found in a small, dark room doing power series expansions on some function for his math methods class or talking about physics to one of his colleagues in the physics department. Occasionally, Daniel likes to go swimming in the river.

Dalton McCuen: Complex Index of Refraction of Multi-walled Carbon Nanotubes in Strong Terahertz Fields.

Carbon nanotubes are the subject of intense interest in virtually every field, from medicine to nano-scale electrical components. Multi-walled nanotubes exhibit a strong nonlinear response to high-field strength terahertz radiation. This research uses terahertz pulses with field strength exceeding 1 MV/cm generated by means of optical rectification utilizing a lithium niobate prism to determine the complex refractive index of free standing highly aligned multi-walled carbon nanotubes wound around a polyethylene reel. Computational techniques are used to determine the index of refraction and extinction coefficient simultaneously as a function of frequency.

Bio: Dalton McCuen graduated from Southridge high school in Beaverton, Oregon, where he grew up. He developed a strong interest in physics his senior year, deciding to major in Physics at Oregon State University. Four years later, he is a senior and will be graduating with a Bachelor of Science in Physics and a minor in Mathematics. He is pursuing a job in the technical industry, and hopes to attend graduate school in Physics or a related field in a year or two. In his free time he enjoys playing and listening to music as well as games of nearly any sort.

Samuel McLain: Leapfrog Integration as an Accurate and Uncomplicated Alternative for *N*-Body Simulations in Computational Astronomy

The ability to obtain highly-accurate data from N-body simulations in astrophysics is important because this leads to more reliable predictions of the trajectory of celestial bodies in our solar system and beyond. The limitations of current computational methods for solving the N-body problem are that cumulative integration errors lead to poor conservation of energy and angular momentum for the bodies involved in the simulation. This poor conservation results in reduced accuracy in position data for long time scales. The leapfrog integration scheme is properly suited to handle the problem of poor conservation because of its unique use of half time steps, which lead to the cancellation of integration error at each full time step. We have shown that the leapfrog integration scheme is a valid alternative for creating N-body simulations by demonstrating that a simulation using this algorithm is capable of providing position data of similar accuracy to higher-order methods. Specifically, we compared data from a simulation using leapfrog integration with data from a simulation using the recurrent power series method under similar initial conditions and saw an acceptable difference in position values for both short and long time scales.

The leapfrog integration method also has promising academic applications because of the simplicity of the algorithm. We are currently preparing an open source release of our simulation using leapfrog integration for its use on the academic level.

Bio: Sam enrolled at Oregon State University as a physics major in the fall of 2011 and is currently a senior. After graduation in June, Sam will going to University of Oregon to join the Master's Industrial Internship Program for the optical materials and devices track.

Abigail Merkel: Designing and Implementing a Portable Interface System for Field-Effect Transistor Biosensors

Biosensors are devices that have a high sensitivity to the presense of biological molecules. Nanoelectronic biosensors utilize graphene and carbon nanotube field effect transistors (FETs) for detecting biological markers. To further research and demonstrate the usability of nanoelectronic biosensors, we want to be able to operate them in a variety of situations. The goal of this project is to design, build, and implement a system that can easily be transported to various locations and provide accurate and real-time data acquisition from a FET.

Using a small Raspberry Pi computer and a digital to analog converter, a user can input the desired gate and source voltages to the FET. An additional circuit reads the current output from the FET, amplifies it, and is read by the Raspberry Pi using an digital to analog conversion. The user can then view the acquired data using a collection of simple data plotting programs on the Raspberry Pi. The entire system consists of small electronic components and circuits, and can easily be transported for easy testing and demonstration of FET circuits.

Bio: Abigail grew up in Hillsboro, OR and graduated high school in 2010. She will be graduating Oregon State this spring with a major in physics and a minor in computer science. After graduation, she will be commissioned as a 2nd Lieutenant and pursue a career as a pilot in the Air Force. In her free time, Abigail enjoys art, music, programming, electronics, firearms, and fast vehicles.

Josh Montegna: Determining the Effective Entropy of a Fractal Visual Hash System

This project investigates the viability of fractal hashes as alternatives to traditional hexadecimal hashes. By finding the effective entropy of the fractal hash system through Bayesian analysis, a measure of how well people can differentiate between images is found. This entropy is compared to the entropy for hexadecimal hashes and used as a measure for the ability of fractal hashes to be used in a cryptographic manner, such as SSH. Overall, fractal hashes were found to be a potentially viable alternative to hexadecimal hashes.

Bio: Josh Montegna came to OSU in 2011 after graduating from high school in Riverside, California. Originally enrolled in nuclear engineering, his interest in understanding the underlying workings of nature quickly caused a major change to physics. During his college career he worked with Dr, Roundy on the visual hash project. His hobbies include tinkering, playing guitar, cooking, and reading. He will graduate with a B.S. in Physics in spring of 2015.

Joshua Mutch: Temperature Dependence of $Cu_{3-x}Sb_{1-y}M_yS_4$ (M=Sn,Ge) Resistivity and Thermopower

Electrical transport properties of variants of bulk Cu3SbS4 are measured to determine its potential as a thermoelectric material. Thermoelectric materials are an active area of research today, with applications in cooling and converting waste heat to useable energy. The resistivity and Seebeck coefficient of bulk Cu3SbS4 and doped variants are measured for temperatures between 10 K and 300 K. Bulk Cu3SbS4 is found to have a room temperature Seebeck coefficient of 800 μV/K, and a resistivity of 4.5 Ω cm. The resistivity behaves semiconductor-like, with an activation energy that increases with temperature, opposite of theoretical prediction. The Seebeck coefficient increases with temperature until 130 K, then decreases with temperature. At temperatures above 130 K, the Seebeck coefficient decreases with increasing temperature, but is not proportional to 1/T. Jonker analysis of the Seebeck coefficient and electrical conductivity does not match a theoretical k/e slope.

Doping with 1% Sn reduces the magnitude of the Seebeck coefficient by ~75%, with even larger reductions for 5% Sn and 5% Ge doping. Doping with 3% copper vacancies results in a relatively small, ~20% reduction in the magnitude of the Seebeck coefficient. Resistivity temperature dependence shows that the 3% copper vacancy doping behaves as a semiconductor, while the samples doped with 5% Sn and Ge have a metallic-like resistivity. Cu3SbS4 doped with 5% Ge displays the highest power factor of the samples measured. PF=1.34x10-4 W/K2m is measured for the 5% Ge sample at 300 K.

Bio: Josh grew up in Jefferson, OR. Josh is a physics major, but also has extensive coursework in computer science. Josh has been volunteering at a thin-films energy transport lab for the past two years, and also has interdisciplinary experience working with engineering students at an energy efficiency lab on OSU campus. His interests include energy efficiency and sustainability, but also a broader interest in physics and experimentation. He is currently planning on attending graduate school at University of Washington in Seattle this fall.

Bao Nguyen: Computational Modeling of Photon Scattering In Gamma Ray Bursts Using Monte Carlo Techniques

The current model for gamma ray bursts (GRBs) suggests that internal shocks are responsible for the emissions of -rays. Internal shocks occur when the photosphere, expanding at a relativistic speed, collides with the slow expanding shell. The light curve of a GRB depends on the initial state of the photosphere. This research focused on examine the photon scattering process occurred the internal shocks phase. Using Monte Carlo Methods and computer simulation, GRBs with different initial parameters were stimulated to obtain the emission light curves. The results for the non-expanding centered photon model showed that cases with the same opacity but different radii produced the same light curve and increasing the radius and the opacity by the same magnitude would not alter the observed light curve. For the non-expanding uniformly distributed photon model, the results also showed that cases with the same opacity but different radii produced the same light curve; however, increasing the radius and the opacity by the same magnitude did not produced the same light curve.

Bio: I got introduced to physics and astronomy in 8th grade. Originally, I wanted to become an astronomy teacher, but after taking astronomy and physics courses, I realized that I could do more than just teaching. My current plan is to pursue a higher education in astrophysics and become a researcher. My interests are dark matter and dark energy. My hobbies are astronomy, traveling, and hiking.

Blythe Nourie: Computational Analysis of Spin Systems in Lattice Using the Heisenberg Model

Seamus O Callaghan: Single Molecule Studies of the Bidirectional Movement of Yeast Kinesin-5/Cin8

Kinesins are molecular motor proteins that use chemical energy from ATP hydrolysis to move along filamentous structures called microtubules inside cells. A kinesin-5 group motor protein found in budding yeast, called chromosome instability 8 (Cin8), has been shown to exhibit bidirectional movement in previous experiments. The mechanisms behind this unusual movement are not completely understood. We used two Cin8 constructs, Cin8(1-560) and Cin8(1-668), which have been shown to be a dimers in theoretical experiments, in varying ionic strength in vitro experiments. At high ionic strength, Cin8(1-560) seems to be unidirectional and Cin8(1-668) appears to exhibit diffusive movement. At low ionic strength, Cin8(1-560)/Cin8(1-668) are inconclusive to show either diffusive or bidirectional movement. These results vary from previous full length experiments, which show Cin8 to be bidirectional at high ionic strength.

Bio: Seamus O'Callaghan grew up in Portland, Oregon and went to high school at Central Catholic. He is graduating with a BS in Physics and plans to go into the industry after college. His hobbies include, hiking, running, reading fiction and playing video games.

Connor O'Driscoll: Hyperspectral Fluorescence and 2-Photon Surface Imaging of "Graphene-like" Dichalcogenides

Transition metal dichalcogenides are being investigated as two-dimensional semiconductors that have potential to replace silicon in optoelectronic devices. We created single layer samples of MoS2 and WS2 by exfoliation which involved repeatedly cleaving bulk pieces of the material with tape, and then applied it to silicon substrates. We measured the photoluminescence of each sample by using a 532 nm constant wavelength laser to excite the materials above their band gap. The enhanced photoluminescence compared to multi-layer regions confirms that there is indeed a single layer of dichalcogenidic material. We can perform further tests on these samples, such as measuring for second harmonic generation. If a sample does not show photoluminescence, then it is either not single layer or the sample has oxidized or been damaged.

Bio: Connor O'Driscoll is a 2011 graduate of Damonte Ranch High School in Reno, NV. Connor applied and receive a Navy ROTC scholarship to Oregon State University, where he pursued a bachelor's of science in physics. Once graduated, Connor will be commissioned an Ensign in the United States Navy and will head to Goose Creek, South Carolina, to study nuclear power.

Michael A. Perlin (Honors College): Optimizing Monte Carlo simulation of the square-well fluid.

We identify and develop efficient numerical methods for determining thermodynamic properties of the square-well fluid in order to test square-well density functional theories. The liquid-vapor phase interface is an interesting regime for testing density functional theories, but unbiased Metropolis Monte Carlo simulations are incapable of sampling the low energy fluid states which dominate the partition function at low liquid-state temperatures. Previous works have developed several generic Monte Carlo histogram methods for collecting statistics on low energy system states, but little or no literature exists on these methods' systematic comparison, as well as their application to the square-well fluid. The square-well fluid in particular introduces application challenges not manifest in traditional models for testing and benchmarking such numerical techniques (e.g. the Ising model).

We implement our own ``simple flat'' method, the Wang-Landau method, transition matrix Monte Carlo, and a modified version of the optimized ensemble. Performance of each method is determined by low energy sampling rates and maximum errors in several computed system properties. We find that Wang-Landau potentially performs better than other histogram methods, but fails catastrophically without a predetermined energy range. The simple flat method and transition matrix Monte Carlo give results comparable to successful Wang-Landau simulations, but simple flat has some anomalous cases with large errors. Finally, our implementation of the optimized ensemble using a transition matrix results in worse performance over the straightforward transition matrix Monte Carlo method.

Bio: Michael A. Perlin grew up in Corvallis, Oregon. He enrolled at Oregon State Univeristy in 2011 as a nuclear engineering major, but soon changed to a physics major with a mathematics minor. Throughout his undergraduate years, Michael conducted research in each of the nuclear engineering, pharmaceutical sciences, and physics departments at OSU, and spent two summers as an intern at NASA's Goddard Space Flight Center. After receiving his B.S., Michael will go to Ulm University in Germany, funded by the German Academic Exchange Service (DAAD), to work in the Quantum Controlled Dynamics Group for a year before applying to physics Ph.D. programs back in the United States.

Alex Poff: Hall Effect in Semiconducting Thin Films

The Hall effect has been used for over a century to measure certain properties of materials. In more recent years, it has been an essential tool in characterizing semiconductors. The Hall effect coupled with Van der Pauw geometry can be used to calculate carrier mobility, carrier concentration, Hall coefficient, and resistivity. These properties are measured with the Lakeshore Hall measurement system, which applies a magnetic field and a current to thin film samples. The system then uses a software program to carry out the calculations. Two materials of interest are indium tin oxide (ITO) and tin sulfide (SnS). Experiments on ITO and SnS produced results including the aforementioned properties. ITO showed a resistivity of 1.65 to 1.67 ohm cm, a carrier concentration of 1.5 x 10^{17} cm^{-3}, and a carrier mobility of 36 $cm^2V^{-1}s^{-1}$. SnS samples varied due to growing temperatures. Mobility and resistivity increased with growing temperatures, while carrier concentration decreased. Resistivity of SnS ranged up to around 200 ohm cm, carrier concentration ranged from 10^{15} to 10^{18} cm^{-3}, and carrier mobility was in the range from 1 to 11 $cm^2V^{-1}s^{-1}$.

Bio: Alex grew up in Albany, OR and graduated from West Albany High school. His college career began when he enrolled at LBCC to play baseball. After two years, he switched his major to physics due to a long-time interest in astronomy and astrophysics. He will be graduating OSU in June with a B.S. in physics. He hopes to begin a career in solar energy upon graduating. He is an avid baseball/softball fan and plays as often as he can.

Mitchell Senger: Framework for Computational Modelling of Cellular Diffusion Systems

Many biological processes are regulated by the presence and movement of cellular Ca2+ ions. The concentration of Ca2+ in a cellular environment is regulated by IP3 sensitive channels that lie on the surface of a cell's endoplasmic reticulum. Little is known about the macroscopic effects of intracellular Ca2+ activity, so these processes are of key interest to the field of experimental biophysics. Experiments that study macroscopic processes that result from intracellular Ca2+ action are difficult to conduct in a lab, so a computational simulation that accurately simulates ion diffusion within a multicellular system is a key tool for studying the large scale effects of intracellular Ca2+ fluctuations.

The product of this thesis is a computational framework for intracellular ion diffusion that will be used as the basis for modelling of multicellular systems in the future. This model generates a spatial boundary from a cell image and overlays a grid comprised of rectangular boxes suitable for discretized diffusion calculations on the cell space. Simulations of particle movement are performed by calculating the particle flux through the boundaries of each box in the grid using Fick's laws of diffusion. An adaptive gridding method has been developed to increase the accuracy of the representation of cellular structures within the grid while greatly increasing calculation efficiency. Efficiency differences between simulations using the adaptive and non-adaptive gridding techniques have been analyzed.

Bio: Mitchell graduated from Dallas High School in 2011 in Dallas, Oregon. He decided to major in physics after one year into his undergraduate career. Mitchell will graduate with a B.S. degree in physics with an option in optics and a minor in chemistry. He will enter the OSU PhD physics program in fall 2015

Samuel Stephenson: Hyperspectral Absorption and Fluorescence Surface Imaging Microscope

As nano-electronics become more prominent, the physics community will undoubtedly need to develop new methods to better analyze optical and electronic material properties. To accomplish this goal we have constructed a device that allows us to measure a material's optical properties over a wide spectrum of light ranging from the ultraviolet (<200 nm) to the near infrared (>1000 nm). The Hyperspectral Absorption and Fluorescence Surface Imaging Microscope (HAFSIM) will provide the equipment necessary to acquire high quality dispersion-free images of these materials with hyperspectral resolution of absorption and fluorescence spectra. The equipment within this device consists of a hyperspectral fluorimeter, xenon-arc lamp light source, double monochromator, reflective objective microscope and electron-multiplying CCD camera. By optically coupling the light source to the microscope we can illuminate a sample at specific wavelengths of light without optical dispersion and subsequently measure both the absorption and fluorescence of the material. This imaging process allows us to perform many important measurements such as bilayer graphene twist region mapping and hyperspectral absorption spectra for single layer dichalcogenides. In addition to the surface imaging setup, the HAFSIM also provides PMT and InGaAs spectrometers and an inspection microscope for orthogonal research projects. We have completed construction of the HAFSIM in its first iteration. Application and scientific accuracy of the device has been verified against literature for sample materials with known absorption and fluorescence spectra including graphene and molybdenum disulfide. Future iterations of the microscope are in continuous development and include spectrally resolved photocurrent measurement and implementation of a transmissive stage. Further applications for this microscope are undoubtedly numerous as new materials become available.

Bio: Samuel Stephenson graduated from West Albany High School in 2009 and became interested in physics after attending Linn-Benton Community College for electrical engineering pre-requisites. He is the first of his family to finish a four year college degree and hopes to work in industry before pursuing a graduate degree in physics or engineering. In his spare time he likes to work on computational physics problems and enjoys video games.

Cameron Thayer-Freeman: Comparison of a Persistent Random Walk to MDA-MB-231 Cancer Cell Chemo taxis through a 2.5D Collagen Matrix

For decades, the model of a persistent random walk has been used to model collective cancer cell migration during metastasis, though recent research shows evidence that the collective motion of cancer cells may be more complex than previously thought, and the model of a persistent random walk may not be sufficient in modeling their motion.

This research specifically examines the collective motion of populations of MDA-MB-231 breast cancer cells under the influence of a chemo-attractant gradient. Their motion is applied to the mathematical model of a persistent random walk, and the persistence bias of the cells is measured. The motion of individual cells is also analyzed; comparing individual and group cancer cell motion to the model of a persistent random walk. The results show evidence towards the conclusion that the collective motion of breast cancer cells does not fit into the model of a persistent random walk, though individualized cell motion within the population does.

Bio:

Austin Valeske (Honors College): Determining Free Energies of Hard Sphere Fluids via Monte Carlo Simulation

Free energy is a fundamental property of a thermodynamic system, from which pressure, entropy, and other interesting properties can be derived. It is useful, then, to be able to accurately compute the free energy at various densities and temperatures in a way that can serve as the basis for further thermodynamic predictions.

We use Monte Carlo simulations to compute the free energy of a homogeneous hard sphere fluid, as a function of the filling fraction. We find the free energy by shrinking a valid configuration in which the component spheres are non-overlapping and checking for overlaps in the smaller volume. We develop techniques to optimize the free energy simulation for speed and accuracy, such as neighbor tables and run length tracking. Finding the absolute free energy is also discussed. This model will serve as the foundation for future simulations of more complex fluids, as free energy is an essential quantity to understand and hard spheres are the standard basis model for fluids.

We find that our free energy simulation agrees with the Carnahan-Starling equation of state, and is able to accurately predict free energy up into relatively dense states. This simulation can serve as the basis for a more complete fluid simulation that includes attractive square well interactions to model phenomena such as surface tension.

Bio: Austin was raised in Portland, Oregon and attended Lincoln High School. While initially a Computer Science major with a minor in Physics, he enjoyed the physics classes so much that he decided to take more of them. He will graduate with a double B.S. in Physics and Computer Science. When not doing research or classwork, Austin enjoys ballroom dance and has been an active member of OSU’s ballroom dance company for the past four years.

Blake Wells: Bandgap measurements of nonspecular materials using a bifurcated fiber optic method of diffuse reflectance

A method for determining bandgap energy using diffuse reflection is presented. The method uses bifurcated fiber optic cables to measure the diffuse reflection of diffusely reflective materials. The absorption spectrum is extrapolated from the diffuse reflection spectrum and used to determine the bandgap of powdered materials. The theory of nonspecular reflection, the Kubelka-Munk model, and bandgap structure is explored. The methods, procedure, and equipment involved in measurements are detailed. The bandgap energies of titanium dioxide, tin sulfide, and 10 percent tin doped indium oxide are determined. The measured bandgap energy of TiO_2 agrees within 0.03 eV of the accepted value. The measured bandgap energy of SnS was inconsistent with the accepted value and is most likely attributable to incorrect infrared spectral data. The measured bandgap energy of $In_{2-x}Sn_xO_3$ agrees within 0.1 eV of the accepted value.

Bio: Blake Wells grew up in south Orange County, California. He graduated Santa Margarita Catholic High School in 2007, and shortly thereafter developed an affinity for Physics. In 2012 he moved to Corvallis, Oregon to pursue a degree in Physics. A few short years later, Blake is graduating with a Bachelor of Science. He plans to work in the microfabrication industry before obtaining a Masters in Applied Physics in the near future. His hobbies include hiking, reading, and cooking.