Oregon State University Department of Physics

SENIOR THESIS PRESENTATIONS WENIGER 304
Refreshments will be served STUDENTS are especially welcome!

Part I: 5 June, 2018

3:00 – 3:10
Ryan Lance: Optical Analysis of Titania: Band Gaps of Brookite, Rutile and Anatase
Advised by Janet Tate

3:12 – 3:22
Alex Quinn: Exploring the Optical and Electronic Properties of Xylindein, a Fungus-Derived Pigment, as a Sustainable Organic Semiconductor
Advised by Oksana Ostroverkhova

3:24 – 3:10
Atilla Varga: Beating modes In proto-stellar disks
Advised by Kathy Hadley

3:36 – 3:46
Darlene Focht: Stellar Disks with Keplarian Rotation and Star-Disk Coupling
Advised by Kathy Hadley

3:48 – 3:58:
Joshua Randolph: Accretion Disk Formation in Newly Formed Binary Black Hole Systems
Advised by Davide Lazzati

4:00 – 4:10
Cassandra Hatcher: Predicting Gamma and X-Ray Polarization from Supernova Remnants
Advised by Davide Lazzati

4:12 – 4:24
Daniel Still: Measurement of Double Layer Capacitance of Single Layer Graphene
Advised by Ethan Minot

4:24 – 4:34
Andrew Lam: Spectral Analysis of Anthradithiophene Derivatives with Polarization Dependence
Advised by Matt Graham

4:36 – 4:46
Collin Muñiz: Synthesis and Characterization of New Rare Earth Niobates
Advised by May Nyman

Part II: 12 June, 2018

3:00 – 3:10
Ryan Ball: Correlating Boxsand.org Web Engagement with Increased Student Performance
Advised by KC Walsh

3:12 – 3:22
Jake Bigelow: Project BoxSand: Impact of Online Course Material and Mastering Physics Interactions on Exam Performance in a Flipped Classroom Environment
Advised by KC Walsh

3:24 – 33:4
Chris May: Freezing a Softly Repulsive Fluid: Monte Carlo Methods and the Weeks-Chandler-Andersen Potential
Advised by David Roundy

3:36 – 3:46
Aaron Dethlefs: The Effect of Annealing Parameters on the Electrical Properties of Fluorine Doped Tin Oxide
Advised by Janet Tate

3:48 – 3:58
Katelyn Chase: Synchronized Cellular Mechanosensing due to External Periodic Driving
Advised by Bo Sun

4:00 – 4:10
Hassan Alnatah: Theoretical and Experimental Analysis of the Length of Actin Filaments in Cancer Cells
Advised by Bo Sun

4:12 – 4:22
Sean Bullis: Using an Optical Trap to Measure Brownian Motion on 3 μ*m* Polystyrene Microspheres
Advised by David McIntyre

4:24 – 4:34
Joel Chantland: Econophysics: Evolving Boltzmann-Gibbs Income Distributions
Advised by David Roundy

4:36 – 4:46
Kyle Tafoya: Modifications to Student Laboratories for Oregon State University's Waves & Oscillations Physics Course
Advised by Matt Graham

Class of 2018 Presentations at previous or future times:

Yousif Almulla: Computing Wavefunctions of Silicon Donor Qubits with Density Functional Theory
Advised by Jacek Jakowski / David Roundy

Matthew Ball: Analysis of Upper Ocean Surface Wave Structure in the Bay of Bengal using χSOLO Floats
Advised by Emily Shroyer

Patrick Flynn: Localized structures in a diffusive run and tumble model for *M. xanthus*
Advised by Arnd Scheel

Fernando Lahiru: Econo-Physics: Lagrangian Mechanics Description of an Economic System
Advised by David Roundy

Jesse Rodriguez: Radial Velocity Profiles and Magnetic Field Probes for Hypervelocity Plasma Deflagration Jets
Advised by Mark Capelli / Janet Tate

Nikita Rozanov: Molecular Dynamics Simulations on Fluorescent Proteins
Advised by Chong Fang

Tanner Simpson: Broad Histogram Algorithm Comparison for the Square Well Fluid
Advised by David Roundy

Abraham Teklu: Using Divertor Strike Point Splitting to Understand Plasma Response and its Sensitivity to Equilibrium Uncertainty
Advised by Richard Moyer / Heidi Schellman

Abstracts and Biographies:

Yousif Almulla: Computing Wavefunctions of Silicon Donor Qubits with Density Functional Theory
Abstract: Silicon based quantum computing is an attractive approach to large-scale quantum computation due to the significant success of the modern semicon- ductor fabrication industry. Despite many advances in silicon quantum com- puting since its inception in 1998, there remains no software for efficiently designing candidate silicon quantum computing devices. Such a develop- ment involves modeling the coherence times of qubits and the fidelity of quantum gate operations in a qubit system, and would accelerate progress towards designing a scalable quantum computer. The quantum computing group at Oak Ridge National Laboratory propose designing a computational workflow for gauging qubit coherence and gate fidelity for Kane's proposal of silicon quantum computing. Kane's model uses electron and nuclear spin states of a P donor atom implanted into a silicon lattice as a qubit, and an oscillating magnetic field to perform quantum gate operations on said qubit. Thus, a computational workflow must consider the electronic structure of a Si:P quantum device, and the wavefunction of the donor electron. This thesis focuses on the donor wavefunction and electronic structure calculations.

The electron density at the phosphorous core gives an approximation to the Fermi contact interaction between nuclear and electron spin states, and is therefore vital to calculating solutions of the time-dependent Hamiltonian representing single-qubit gate operations in Kane's model. We use the Vi- enna *ab-initio* Simulation Package (VASP) implementation of density func- tional theory to compute the valence electron wavefunction of a phospho- rous defect in a 1.08 nm silicon nanocluster, and the charge density of this electron. We find the electron density to be orders of magnitude below the true electron charge density at the phosphorous nucleus. These data sug- gest that the pseudo-wavefunctions used by VASP are not accurate enough to inform a silicon quantum computing modeling code.

Bio: Yousif Almulla is an undergraduate interested in pursuing quantum computation and condensed matter physics during his research career. As a student, Yousif co-founded a science and engineering innovation club (Inventors Enterprise), organized and participated in the H-Weekend hackathon event in the College of Engineering, and mentored minority high school students in the SESEY scientific outreach program at Oregon State University. Yousif is graduating with an Honors degree in Physics and Mathematics, and after a summer research fellowship at Los Alamos National Laboratory, will be continuing his studies at Oxford University in an M.Sc. for Mathematics and the Foundations of Computer Science.

Hassan Alnatah: Theoretical and Experimental Analysis of the Length of Actin Filaments in Cancer Cells
Abstract: The migration of cancer cells is a complex process requiring drastic remodeling of the cell cytoskeleton. Elongation of actin filaments at the leading edge of migrating cells is thought to assist the migration of cancer cells. Imaging the structures of actin filaments allows analysis of the response of cytoskeleton to mechanical stimulation, but it also imposes challenges in the image processing stage. These challenges include the presence of imaging-related artifacts and heavy blurring introduced by the optical elements of the microscope. In this paper, we develop a deconvolution algorithm to remove the image-related artifacts from actin-stained cancer cell images. We then pro- pose a mathematical model to explain the filament length distribution by using a non-biased Markov chain model. We find that our deconvolution algorithm drastically reduces the out-of-focus light in the convolved images, resulting in sharper images of the actin filaments. Furthermore, we find that our filament length model quite accurately represents the length distribution of actin filaments with only a couple free parameters. These free parameters are the polymerization/depolymerization rate k and the branching rate k_{br}.

Bio: Hassan Alnatah grew up and attended high school in Qatif, Saudi Arabia. He attended Oregon State University in September of 2014 and is graduating in June of 2018 with a double major in physics and biochemistry. During his time at OSU, he conducted research with Dr. Bo Sun in cellular biophysics. After graduation, he plans to attend graduate school to study theoretical cellular biophysics or computational neuroscience.

Matthew Ball: Analysis of Upper Ocean Surface Wave Structure in the Bay of Bengal using χSOLO Floats
Abstract: Surface waves play a vital role in air-sea interactions, and being able to easily measure them in-situ validates and improves predictive models. Here, we diagnose surface wave properties in the Bay of Bengal using modified vertical SOLO II profiling floats, which are regularly used as part of the Argo ocean float array. The modified χSOLO floats measure high frequency pressure, acceleration, velocity fluctuations, and turbulence data, in addition to traditional conductivity-temperature-depth data. The pressure and acceleration data are used to compute surface wave frequency and height for swells and surface wind waves. The frequency of the swells is computed using power spectral density of vertical acceleration at the bottom of a vertical dive, and surface wind wave frequency is computed using power spectral density of the pressure record while at the surface. To find amplitude, the observed frequencies are individually identified in depth-binned Fourier transforms of the net horizontal acceleration. The magnitudes of these Fourier components are fit to an exponential decay as a function of depth, and the terms of this fit give the

amplitude of the wave component corresponding to that frequency. These methods unveil a series of swells of roughly half meter amplitude generated between 7000 km and 9500 km away and two short period wind wave bands of ~ 4 s and ~ 7 s with amplitudes 0.1 m and 0.3 m, respectively. The observed waves agree well with model predictions from the global WaveWatch III simulations.

Bio: Matthew Ball is a senior at Oregon State University and is pursuing an Honors degree in physics with a minor in mathematics. He grew up in Grants Pass, Oregon before jumping straight into a physics degree at Oregon State. Matthew completed an REU in the summer of 2016 working with various ocean data through Oregon State's College of Earth, Ocean, and Atmospheric Sciences. He returned to the same REU program the following summer to continue working on ocean wave detection, which would become his Honors Thesis. After graduation, Matthew will be pursuing a PhD in physics at the University of Oregon.

Ryan Ball: Correlating Boxsand.org Web Engagement with Increased Student Performance

Abstract: The focus of this study is how students' grades are affected by their interactivity within the BoxSand website. In 2016-17, at Oregon State University, the students' interactions were studied while taking the Physics 20x fall, winter, and spring classes. These classes were taught using a flipped classroom design with the instructional material provided by the BoxSand website. The website is designed to provide the material for the course. The interactions by the students are then recorded so it can be evaluated to improve their learning. This study explored the correlations between how students interact within the site and changes in their grades.

The results of the video research showed that the students with the greater average number of views consistently for each week earned higher grades in the class. The behaviors of the students change on the weeks with exams. The students with lower than average grades will tend to view more videos, while students with the higher average grades will either keep the same viewing habits or slightly increase the number of videos watched.

The results of the overall interactions within the site showed that positive changes in behavior (increased interactions) on the site correlated with increase in exam grades overall. If students changed their behavior in a negative manner (fewer interactions), their grades tended to go down on the next exam.

Bio*:* Ryan Ball is a senior, majoring in Physics at Oregon State University. He is interesting in pursuing work in rocketry and working for the Department of Defense. He graduated from Marshfield Senior High School, located in Coos Bay, OR in 1996. While in high school he enlisted into the U.S. Army. Days after graduation he left for basic training and AIT to specialize in logistics. After serving 3 years in the Active Army, Ryan left to the civilian sector but still worked 5 more years in the Oregon Army National Guard. During that time he started work in the entertainment industry and became a technician for Spirit Mountain Casino. During his time at the casino he worked his way up to become the Technical Supervisor. After 13 years at the casino Ryan left to continue his education. He pursued his AAOT degree at Chemeketa Community College. After receiving that degree he transferred over to Oregon State University to earn his degree in Physics. He is currently a teaching assistant and a research assistant as a member of Professor K.C. Walsh's research group. Ryan plans to graduate this spring and to actively pursue employment locally for the next two years before trying for a DoD position.

*Jake Bigelow***:** *Project BoxSand: Impact of Online Course Material and Mastering Physics Interactions on Exam Performance in a Flipped Classroom Environment*

Abstract: A flipped classroom provides students with course content in the form of videos, readings, and/or simulations that they complete during the time traditionally used for home- work assignments while in-class time is devoted to hands-on group learning activities. Project BoxSand is gathering quantitative data on how students in a flipped classroom, algebra-based introductory Physics series, interact with the course website and other online components or materials. Using educational data mining methods, I analyzed student use of the Mastering Physics by Pearson website used for homework submission, and the impact on exam performance. I found a positive correlation between the completion of the Post-lecture Mastering Physics assignments by the due date and exam performance. Students completing Post-lecture Mastering Physics assignments by the due date tended to perform better on exams than students who either didn't complete the assignments or completed them after the due date.

Bio: Jake Bigelow is receiving a Bachelor of Science in Physics, with a Physics Education Option, from Oregon State University in June 2018. He will be starting the Masters of Science in Science Education program at Oregon State University in August 2018, with plans to teach Physics at a public high school in the Seattle area upon completion of that degree. Mr. Bigelow's undergraduate research focused on learning analytics and educational data mining in the field of Physics Education Research, specifically working with Dr Kenneth C Walsh at Oregon State University on Project BoxSand.

Sean Bullis: Using an Optical Trap to Measure Brownian Motion on 3 μm Polystyrene Microspheres

Abstract: The current theory of Brownian Motion accounts for the thermal interactions between particles in a solution to determine the mean squared displacement of an individual particle over time. Optical trapping allows small particles to be held in place and by using Mean Squared Displacement (MSD) averaging the Brownian motion of an individual particle can be measured, in this case down to 16.7 *ms*. This experiment uses an optical trap to measure the Brownian motion of 3 micron polystyrene particles and uses MSD averaging to measure Brownian motion at these time scales. The results show that the Brownian motion can be measured using this method, however subtle experimental errors can lead to unexpected results. Surface cohesion and optical misalignment prove to be likely culprits when measuring Brownian motion with an optical trap. A key limitation to the experiment is the framerate of the camera which limited the resolution of our data to 16.7 *ms* . The data collected follows the trends expected from previous experiments and by minimizing or completely eliminating the effects of surface cohesion and optical misalignment and increasing the framerate of the camera better data can be obtained.

Bio: Sean Bullis is a native Oregonian growing up in Lake Oswego, Oregon. He is an undergraduate senior studying Physics at Oregon State University. Sean has an interest in electronics development and hopes to work in industry. Sean has worked as a TA in the physics department for Christopher Coffin for the past year, as well as conducting research in Dr. McIntyre's lab. Sean also worked as a field assistant in the Plant Breeding and Genetics department at OSU for a year and a half assisting in aroma hops research. In his spare time Sean enjoys reading, playing tennis and biking. Sean will graduate spring 2018 with a B.S in Physics.

Joel Chantland: Econophysics: Evolving Boltzmann-Gibbs Income Distributions

Katelyn Chase: Synchronized Cellular Mechanosensing due to External Periodic Driving

Abstract: The response of cells to periodic driving is important for many biological processes, particularly blood flow and heart functioning. Our research analyzes the collective shear stress response of fibroblast cells due to a periodic driving frequency. When cells experience shear stress, they release calcium into the cytosol. To quantify the shear stress response of the cells, we use calcium imaging and single-cell level analysis. We had previously observed that the average collective calcium response of a monolayer of fibroblast cells had a different frequency than the applied periodic shear stress. Upon further testing, we ran into difficulties with air bubbles that caused the previous results to not be repeatable. We developed a new, more stable procedure including the use of a flow controller and a bubble trap. This work analyses the old procedure, the previous data, and the new procedure. With the changes made, we were able to successfully develop a new procedure to run the periodic shear stress tests.

Bio: Katelyn Chase grew up in Roseburg, Oregon. After high school, she attended Umpqua Community College for a year, where her physics professor inspired her to pursue a degree in physics. She then transferred to Oregon State University and will be graduating Summa Cum Laude with a degree in physics. Shortly after transferring, she joined Dr. Sun's experimental cell biophysics lab. During her undergraduate years, she received the Summer Undergraduate Research Experience (SURE) scholarship at OSU, participated in a Research Experience for Undergraduates (REU) at the University of Utah, and received the Undergraduate Research Innovation Scholarship and Creativity (URISC) grant at OSU. In October 2017, she published her first author paper "Enhanced Stability of Kinesin-1 as a Function of Temperature" in the Biochemical and Biophysical Research Communications journal. Next year, she will be attending Princeton University to pursue a Ph.D. in Quantitative and Computational Biology. She later plans to pursue a career in biophysics research, specifically in academia.

Aaron Dethlefs: The Effect of Annealing Parameters on the Electrical Properties of Fluorine Doped Tin Oxide

Thin film oxides are useful conducting layers that are used in many applications ranging from LCD monitors to heat mirrors. High mobility oxides are of specific interest because they are needed to create more efficient conducting surfaces. This paper studies the effect of annealing temperatures on fluorine-doped tin oxide (FTO) annealed in both air and forming gas composed of 95% argon and 5% hydrogen. The Hall mobility, carrier concentration, and resistivity were measured using a 7504 model Lakeshore Hall Measurement System at room temperature. It was found that FTO annealed at 700C in air has a mobility of 27 cm^2/Vs and FTO annealed at 500C has a mobility of 5 cm2/(Vs). When forming gas was introduced to the annealing process the mobility of samples was lower than samples formed in air. Possible reasons for the improved mobility as a function of temperature are discussed through a comparison to tin doped indium oxide.

Patrick Flynn: Localized structures in a diffusive run and tumble model for M. xanthus

Abstract: The bacteria Myxococcus xanthus clusters into fruiting bodies in the absence of food. The movement of *M. xanthus* has three aspects: self-propulsion (run), change of direction due to collision (tumble), and Brownian fluctuations in movement. We propose a minimalist PDE model for the concentrations of left and right moving agents in one-dimension that incorporates these three phenomena as advection, diffusion and reaction respectively. We proceed to analyze stationary solutions to this equation, utilizing geometry and dynamical systems theory to show existence of families of concentration profiles representing localized peaks or troughs in an otherwise uniform concentration. We verify and extend these existence results by computing cluster and gap type solutions with numerical continuation methods. We also demonstrate temporal stability of the clusters and gaps with numerical experiments. Phenomenologically, we find that these profiles form due to a combination of the left moving population blocking the forward movement of the right moving population and vice-versa, and dampening due to diffusion.

Bio: Patrick Flynn hails from Tualatin, OR. After enrolling in Oregon State University, he discovered his passion for mathematics and physics. His primary interests lie in the areas of the analysis of dynamical systems and partial differential equations, and connections to physics and modeling. These interests were partially shaped by a summer research project with Radu Dascaliuc in the OSU math department and later the “Complex Systems” REU at the University of Minnesota with Arnd Scheel. He also contributed linear solver code for the Monte-Carlo simulations performed by the Roundy research group. During his Junior and Senior years, he placed first on the annual Putnam math *competition* out of OSU students. He also plays jazz guitar and enjoys drawing.

Darlene Focht: Stellar Disks with Keplarian Rotation and Star-Disk Coupling

Abstract: We examined protoplanetary star-disk formation, with Keplarian rotation and one, two, and three density waves within the disk. Several past studies have advanced the computational techniques used to model these systems; in this paper, we examine the addition of gravitational coupling between fluid in the disk and fluid in the star, for q=1.5 rotating fluids. These results are compared briefly with results from a paper investigating similar systems with q=2, and found that star-disk coupling was stronger in the q=1.5 modes. We also investigated how the flatness of the central star affects the coupling between and in general found that flatter stars have stronger coupling contributions to the formation of density maxima.

Cassandra Hatcher: Predicting Gamma and X-Ray Polarization from Supernova Remnants

Abstract*:* Determining the polarization of the electromagnetic radiation is a very important diagnostic tool used to determine the mechanisms at work in sources of radiation. Gamma and x-rays are the highest energy form of light with limited number of mechanisms and sources that can produce these rays. Cosmic sources such as jets from super massive black holes, gamma ray bursts, and supernovae can produce gamma and x-rays. Understanding the mechanisms present can help evolve our understanding of these violent cosmic events. There has yet to be a clear theoretical model for observers to test their results against. There are models created for specific experiments but no wide-ranging dynamic model. This project aims to create a theoretical backing that which observations can be tested. We create a Monte Carlo simulation in Python that predicts the polarization of gamma and x photons as they exit an electron cloud created by a supernova explosion. There are specific requirements that need to be met based on geometry of the electron cloud and Compton scattering equations. These requirements have been met and are illustrated in the polarization trends presented. This simulation is successful at predicting the polarization of photons from such an event and is ready to be developed deeper to create a more realistic environment.

Bio: Cassandra Hatcher is a senior at Oregon State University concluding her bachelor of science in physics. She is interested in pursuing a career in astrophysics research at NASA. She has been preforming astrophysics research under Dr. Davide Lazzati since her sophomore year. She received a NASA summer internship and spent the summer of 2016 measuring sodium in the lunar corona at NASA’s Goddard Space Flight Center. This lead to an opportunity to take images of the lunar corona with the McMath Telescope at Kitt Peak Arizona the following fall. These experiences helped her receive a summer REU through Oregon State University in the summer of 2017 to fund her continued work with Dr. Lazzati. This summer she will be working with Dr. Allison Kirkpatrick, a future professor at the University of Kansas, to create a catalog of AGN+ star forming galaxies and X-ray stacking analysis. This will lead her into her graduate studies at the University of Kansas to pursue a PhD. in physics.

Andrew Lam: Spectral Analysis of Anthradithiophene Derivatives with Polarization Dependencestract:

Abstract*:* Organic photovoltaics are being explored as the next generation material for semiconducting and opto-electronic devices but are limited by their stability and efficiency. One possible solu- tion is crystallized anthradithiophene (ADT), which is a promising photovoltaic material due to its high quantum yield and contain adjustable side structures attached to the core molecule. The side derivatives TES-F, TDMS-F, and TSBS-F, change the distribution of excited state electrons, affecting charge transfer in the crystal system without variance of the molecule’s optoelectronic properties. Previous experiments have observed the absorption, reflection, and transmission spectra of these derivatives in solution with respect to the polarization of incident light but the transition of excited electrons at specific bands has not been explored. Measurements on this behavior could decrypt information about this relatively unknown sample. Additionally, discovering the different H-aggregate and J-aggregate dipole orientations of these samples would allow higher solar cell efficiency through excitations of a specific type of coupling.

An analysis of these side groups is done by measuring a photoluminescence excitation spectrum of ADT and the spectra is compared against the absorption as a function of wavelength. By varying the wavelength of incident light on

the sample using a monochromator system, an EMMCD camera captures the response of the sample as it is being excited. The response is recorded as a function of the wavelength of incident light and single domain regions are analyzed. By analyzing multiple emission peaks and isolating these bands, we compare the excitation spectra across different bands to the absorption spectra, confirming non-unique transition behavior across each derivative and determine that each PLE spectra fits to the absorption spectrum through a scalar constant.

From the polarization of light on the sample, we find a tunable response that determines an H-like and J-like response from the system, isolating a specific angle that maximizes the coupling from the H or J-aggregate dipole orientation. TES-F appears maximally J-like at 45˚ and maximally H-like at 117˚. TDMS-F has a maximum J-like response at 90˚ and a maximal H-like response at 45˚. TSBS-F exhibits J like behavior across all polarization measurements, with 90˚ being the strongest.

Bio: Andrew Lam is a senior in Physics at Oregon State University, he has been conducting organic photovoltaic research within Dr. Graham's lab. He was recently admitted to the University of Oregon Advanced Material Analysis and Characterization Program and will begin classes there during the fall. He currently works as a peer advisor within the College of Science, helping students find success and opportunities within the field of science. He also works as a teaching assistant, leading a lab section for the topics of electromagnetism and circuitry. Along with his school commitments, Andrew has been actively involved in multiple cultural clubs throughout his 4 years at OSU, participating in shows, events, and leadership workshops.

Ryan Lance: Optical Analysis of Titania: Band Gaps of Brookite, Rutile and Anatase

Abstract: Semiconductor devices play a paramount role in our everyday life. They comprise the critical technology present in all modern electronic devices. We have used semiconductors to perform vast amounts digital logic instantaneously, connect people across the world, generate power from sunlight and more. We are constantly fighting to improve the quality and abilities of our devices and generate new technology. In pursuit of new semiconducting materials, we have investigated the properties of titania (TiO_2). TiO_2 is a wide bandgap semiconductor with three common stable phases: anatase, the ground state rutile, and the less common brookite phase. Brookite is the least stable phase, but our lab has determined the conditions in which it grows from an amorphous precursor. High-fraction films of each of the three polymorphs were created in our lab and characterized using optical spectroscopy. With the help of optical analysis software called SCOUT, we created models for the dielectric function with which SCOUT produced theoretical transmission and reflection spectra. SCOUT's parameter fitting algorithm matched the theoretical data to the experimental measurements—thus achieving a solution to the dielectric function that contained properties of the film. With SCOUT optically modeling our films, we accurately characterized the band gaps of brookite, anatase and rutile.

Bio: Ryan Lance attended Linn-Benton Community College for two years, earning his Associates of Science. At LBCC he was on the Remotely Operated Vehicle (ROV) Team for two years and competed in the international MATE competition in 2015. In the fall of 2016 he transferred to Oregon State University and began doing research in Dr. Tate's thin films lab. In the Tate lab, Ryan learned how to perform optical characterization on thin films. He learned how to construct a model for the dielectric function of semiconducting materials, and coded the modeled with Mathematica and python to better understand the material responses. He mastered an optical characterization software called SCOUT and used it to perform measurements on thin films using sophisticated dielectric models. With SCOUT, he characterized high phase fraction brookite, anatase and rutile films. Working in the lab gave him the experience he required to be accepted into the University of Oregon's Master's Industrial Internship Program. There he will complete his Master's degree in Applied Physics and enter the semiconductor industry.

Chris May: Freezing a Softly Repulsive Fluid: Monte Carlo Methods and the Weeks-Chandler-Andersen Potential

Abstract: The equation of state for a fluid described by the Weeks-Chandler-Andersen (WCA) potential was solved to determine at what pressures and temperatures the fluid will theoretically freeze. A Monte Carlo (MC) algorithm was used to sample a system of 256 spheres for a set of thermodynamic averages to locate and confirm a phase transition. A thorough discussion of the basics of the Metropolis MC algorithm and the derivation of thermodynamic averages for WCA are developed. The phase transitions over varying densities and temperatures were found and used to plot a pair of phase diagrams which describe the equation of state. The WCA potential is a modification of the Lennard-Jones potential and it treats intermolecular potentials as fully repulsive which means there is no liquid state. Its implementation into density functional theory (DFT) has been of interest to the Roundy research group for some time, and to determine whether or not the DFT is accurate the group needs to compare results with the MC. The WCA potential is used as a model for crystal growth kinetics and dendrimers, so simulations that better model the properties of those categories of materials can provide greater insight into their behavior.

Bio: Chris May, a native of Prescott, Arizona was the captain of the Arizona State University roller hockey team, which he led to consecutive national championship tournaments. In the fall of 2016, he began pursuing a post-baccalaureate degree in Physics at Oregon State University where he gained teaching experience as an undergraduate TA for the PH21X series. Due to his research and enjoyment of computational physics he has been accepted into the Optical Materials and Devices track of the Master's Industrial Internship Program at the University of Oregon for summer 2018.

Collin Muñiz: Synthesis and Characterization of New Rare Earth Niobates

Abstract*:* Rare-earth (RE) coordination polymers are infinitely tailorable to yield luminescent materials for various applications such as solid state lighting, sensing, and optics, because trivalent rare earth ions emit intense, monochromatic visible/near IR radiation when provoked with UV radiation. Although RE materials have made there way into technology, they are typically inefficient in the context of energy. That is, they consume much more energy than they provide. Further, the majority of commercial RE materials are doped powders, which can be difficult to reproduce.

Here we described the synthesis of a heterometallic rare-earth coordination compound ((CH3)2SO)3(RE)NbO(C2O4)3 ((CH3)2SO) = dimethylsulfoxide, DMSO, (C2O2 = oxalate), (RE=La, Ce, Pr, Nd, Sm, Eu, Gd, Tb). The structure was obtained from single crystal X-ray diffraction of the La analogue. The Nb=O and DMSO terminal-bonding character guides assembly of an open framework structure with noncentrosymmetric RE-coordination geometry, and large spacing between the RE centers. A second structure was observed by PXRD for the smaller rare earths (Dy, Ho, Er, Sm, Yb); this structure has not yet been determined. The materials were further characterized using FTIR, and photoluminescence measurements. Characteristic excitation and emission transitions were observed for RE = Nd, Sm, Eu, and Tb. Quantum yield (QY) measurements were performed by exciting Eu and Tb analogues at 394 nm (QY 66%) and 464 nm (QY 71%) for Eu; and 370 nm (QY=40%) for Tb. We attribute the high QY and bright luminescence to two main structure-function properties of the system; namely the absence of water in the structure, and absence of concentration quenching.

Alexander Quinn: Exploring the Optical and Electronic Properties of Xylindein, a Fungus-Derived Pigment, as a Sustainable Organic Semiconductor

Abstract: Xylindein is an organic pigment derived from *Chlorociboria aeruginascens* and *C. aeruginosa* fungi that has shown promise as an organic semiconductor. Preliminary estimates of charge carrier mobilities (CCMs) on the order of 0.1 cm2/V×s were calculated from early tests on xylindein thin films, and photocurrents were also observed under laser stimulation. As part of the ongoing effort to characterize xylindein and improve its quality as a possible semiconductor, a broad set of experiments were performed testing the optical and electronic properties of xylindein in solutions and bulk films, and attempts were made, using techniques like solvent vapor annealing, to improve the electronic quality of xylindein thin films (as measured by CCM). In addition, the electronic properties of xylindein and some of its isomers were calculated using Gaussian 09. The details of these experiments and their results are outlined in this report, with comparisons made between the observed characteristics of xylindein and those of other organic semiconductors.

Xylindein absorbs strongly in the visible range, with a peak molar absorptivity near 8600 1/M×cm, but fluoresces very little compared to other organic semiconductors, indicating some strong mechanism for non-radiative decay in both dissolved and bulk xylindein. Xylindein shows strong signs of intermolecular hydrogen bonding through both a 30-60 nm red shift in the absorption spectrum in protic solvents as well as a tendency to start showing bulk properties in spectroscopic data at a lower range of solution concentrations than other organic semiconductors. The high preliminary charge carrier mobilities observed were not successfully replicated, but efforts to improve thin film quality were unsuccessful or even counterproductive. Computational results for enthalpy of formation ΔHf show a difference of less than 0.1 kcal/mol between xylindein and one of its isomers, suggest that xylindein could potentially spontaneously self-isomerize. The isomers of xylindein were also calculated to have vastly different HOMO-LUMO gaps, with sizes ranging from 1.70 to 2.24 eV, than xylindein itself.

Bio: Alex Quinn was born in California and grew up in Salem, Oregon. He attended Chemeketa Community College after graduating high school in 2013 and explored computer science and chemistry before settling on studying physics. Alex transferred to Oregon State University in 2015, at which point he joined Dr. Oksana Ostroverkhova's lab and began assisting with research on the optical and electronic properties of biologically-derived organic materials. After graduation, Alex will begin graduate work in physics at the University of Oregon.

Joshua Randolph: Accretion Disk Formation in Newly Formed Binary Black Hole Systems

Abstract: Throughout history, nearly everything that we have found out about the universe has been discovered by electromagnetic radiation. Black holes are regions in space in which the gravitational field is so strong that not even light could escape if it were to enter. This creates a problem for astronomers trying to study these objects; how can you study something that you can't see? It is for this reason that accretion disks around black holes become so important.

This research project attempts to explain how these accretion disks form in a binary black hole system, and how different mass configurations could affect the region in which a test mass would become part of this disk. This is done by creating a Python code that simulates a test mass around one of the black holes in a binary system, running the simulation for a given amount of time to see where the test mass would end up, then changing the test mass' initial position and running the simulation again. This process is repeated enough times until a map could be made describing the ending regions for a collection of test masses that formed a circle around the newly formed Black Hole. This map helps explain how these accretion disks form and, in turn, explains the physical aspects of the Binary Black hole system itself.

Bio: Joshua Randolph is a Senior at Oregon State University majoring in Physics. He was raised in Beaverton, Oregon and attended Beaverton High School, graduating in 2014. His interest in Astronomy fueled his reasoning for majoring in Physics at Oregon State University. Outside of school, he has been Vice President of his fraternity, along with Vice President of Scholarship for the Interfraternity Council at Oregon State University. After graduating, he plans on taking a year off and working in the Energy sector before going to Eastern Michigan University to pursue his Masters degree in Physics.

Jesse Rodriguez: Radial Velocity Profiles and Magnetic Field Probes for Hypervelocity Plasma Deflagration Jets

Abstract: The fundamental physics of turbulence in plasma is not well understood. Recent studies of the plasma deflagration accelerator in the High Temperature Gasdynamics Lab at Stanford University have demonstrated the presence of small-scale instabilities that limit the lifetime of the jet/Z pinch and are not reproduced by coaxial plasma accelerator simulations. To provide more data to inform these simulations, a radial profile of axial velocity was measured using spectrometry. Magnetic field probes utilizing chip inductors were de- signed to produce well-behaved results at high frequencies, enabling the use of techniques like wavelet decomposition to identify the fastest-growing instabilities in the flow.

The velocity measurement produced a radial profile of axial velocity that was consistent with prior experimental data and reproduced key features of the simulations. The core of the jet was shown to travel uniformly at 92 ±5 km/s out to a 5 mm radius, and the shear flow around the jet rose to ~120 km/s at 10 mm. An impurity emission line (Fe I) was used to generate the velocity profile and thus the experiment may have failed to capture features tied specifically to the physical characteristics of the plasma species. Doppler and Stark broadening measurements revealed the presence of artificial broadening which increased the uncertainty. The magnetic field probe project produced prototypes that measure axial, azimuthal, and radial field variation. A calibration procedure for the probes was designed and demonstrated. The calibration curve shows the onset of resonances at ~10 MHz, calling for improvements to achieve the desired maximum operating frequency of 100 MHz. The curve also suggests that the probe will produce a signal of order ~1 V during operation, showing that the circuit components are sufficient for detection of the fine structure of the magnetic field.

Bio: Jesse Rodriguez is a senior in the Honors College at Oregon State University with a triple major in Physics, Mathematics, and Nuclear Engineering. Jesse has completed three research projects during his undergraduate studies at Oregon State University, the University of Chicago, and Stanford University. At Oregon State, Jesse used computational fluid mechanics models to explore subsurface flows in granular media in an effort to better understand why sand dries out under footsteps at the beach. At the University of Chicago, Jesse analyzed diffuse interstellar bands in absorption spectra from various stars in order to discern what types of molecular species are present in interstellar space. At Stanford, Jesse measured spatially resolved axial velocity of the jet formed by the Stanford plasma deflagration accelerator and designed new high frequency magnetic field probes. The velocity profile obtained in this study will inform existing coaxial plasma accelerator numerical models and the magnetic field probes will allow for identification of the fastest growing micro-instabilities that limit the Z pinch lifetime. Jesse will begin his PhD studies at Stanford University in Autumn 2018 and will continue to build upon his prior work there.

Nikita Rozanov: Molecular Dynamics Simulations on Fluorescent Proteins

Abstract: Fluorescent proteins have emerged as an essential toolset for bioimaging, creating a demand for engineering proteins with new and improved fluorescent properties. In this thesis, I explore the atomistic structure of REX-GECO1, a newly engineered protein biosensor that has unique optical properties. Since this protein has no available crystal structure, understanding the relationship be- tween its structure and properties is difficult. To overcome this challenge, I use molecular dynamics simulations to predict the protein's structure and use this information to identify structural features that influence fluorescence. Moreover, I use the simulations to obtain thermodynamic information that provides further detail about the protein. These findings will be useful for understanding data obtained from ongoing ultrafast spectroscopic studies.

Tanner Simpson: Broad Histogram Algorithm Comparison for the Square Well Fluid
Abstract*:* Thermodynamic properties of systems are often investigated computationally. Traditionally, thermal physics simulations are limited by their very small energy ranges and slow convergence. Broad histogram algorithms are a class of Monte Carlo algorithms that can explore an entire energy (and temperature) range in one thermal physics simulation: potentially saving months of compute time. In this paper, we investigate broad histogram methods designed inside (SAD, TMI, and TOE) and outside (Wang-Landau, Transition Matrix Monte Carlo, Wang Landau Transition Matrix Monte Carlo, and Stochastic Approximation Monte Carlo) of the Roundy re- search group. The square well potential of thermodynamics serves as the algorithm-testing platform. This thesis covers the motivation and theory behind each histogram method. We then investigate algorithm performance on two sets of system configurations by analyzing their uncertainty and error when computing each system's entropy over time.

Overall, three algorithms developed in group, SAD, TMI, and TOE consistently converged to low errors. In addition, SAD, TMI, and TOE were straightforward to prepare for simulation, as there aren't any user-defined parameters. Wang-Landau Transition Matrix Monte Carlo (WLTMMC) converged to low error and low uncertainty rapidly, but required a predefined energy range. This research demonstrates that the popular Wang-Landau algorithm (while collecting lots of independent samples) does not work well for all systems and can converge to incorrect values of a system's entropy.

Bio: Tanner Simpson is a third year physics major at Oregon State University. Growing up in rural Southern Oregon, he has a love for science, arguing, and the outdoors. His undergraduate research analyzes Monte Carlo methods applied to the square well fluid of thermodynamics. He currently works as a teaching assistant for the general physics sequence and has previously worked as a lab assistant in Oregon State's Mass Spectrometry Center. Tanner will be attending the University of Rochester in the fall, with the goal of studying optics and plasma physics at the graduate level. He ultimately aims to study nuclear fusion, ideally as a research professor or scientist.

Daniel Still: Measurement of Double Layer Capacitance of Single Layer Graphene
Abstract: Graphene's double layer capacitance plays an important role in future energy storage devices and biomedical sensors. I measured the double layer capacitance of single layer graphene on soda lime glass substrate by asymmetric and symmetric capacitor design with polyvinyl alcohol gel electrolytes. Untreated glass substrate was used in asymmetric design and provided capacitance measurements of 2.95uF/cm^2 and 2.98uF/cm^2 for 100mV/s and 500mV/s scan rates respectively; however, the working electrode showed evidence of corrosion during subsequent measurements. A number of additional devices were fabricated, but failed for various reasons. Two characterization techniques proved useful for determining the source of failure. The first technique is based on electrical resistance measurements across the graphene on glass. The second technique is based upon oxidization of copper foil.

Bio: Daniel Still is from Pleasant Hill Oregon. After completing high school, he joined the Navy as a Hospital Corpsman. He served for four years in the service and during this time deployed to Africa. Several years after completing service, he attended Lane Community College focusing on Physics. After graduation from Lane, Daniel began attendance in the physics program here at Oregon State. After graduating this summer, he plans to take several months off to spend time with his newborn daughter and then pursue work in industry.

Kyle Tafoya: Modifications to Student Laboratories for Oregon State University's Waves & Oscillations Physics Course
Abstract: Several modifications were made to the in-class student laboratories for the Waves and Oscillations physics course at Oregon State University. There are three in-class laboratories which students conduct during the course. The first laboratory is a series inductor-capacitor-resistor (LRC) experiment which demonstrates electrical resonance, admittance, and phase. The second laboratory is a a fast Fourier transform (FFT) experiment where students Fourier transform (FT) a delta impulse waveform processed through a series LRC circuit. The third laboratory is a coaxial cable experiment that demonstrates the reflection and transmission of a voltage wave propagating through a coaxial cable. The laboratories were updated to improve the accuracy of experimental data measurements, to boost laboratory time efficiency, and to provide students with a more intuitive understanding of the laboratory physics.

The series LRC laboratory was modified by the implementation of an amplifier and speaker into LRC circuit. The speaker allowed students to hear the tonal quality of various waveforms, as well as compare the tonal quality between the input waveform signal and the subsequent LRC output signal. The impulse FFT LRC laboratory also received the amplifier and speaker with the addition of a FFT software called Daqarta. Daqarta gave students the ability to Fourier transform the audible input or output signals, emitted by the speaker, producing various graphical representations of the Fourier transform. Lastly, the coaxial cable laboratory was updated with a dial potentiometer allowing students to make faster resistance measurements, compared to previous methods, as well as improving measurement accuracy. Informal discussions with Dr. Graham and the Oscillations & Waves student class suggest the laboratory modifications enhanced the students' comprehension of the laboratory physics and improved their experimental data results.

Bio: Kyle Tafoya is a senior undergraduate in the physics program at Oregon State University. Mr. Tafoya grew up in California, spent time in the military, and subsequently moved to Oregon. His interest in physics was catalyzed by the late, great educator Carl Sagan. Kyle will be leaving academia after graduation.

Abraham Teklu: Using Divertor Strike Point Splitting to Understand Plasma Response and its Sensitivity to Equilibrium Uncertainty

Abstract: Soon the largest fusion project in the world, ITER, will attempt to produce more fusion power than required to sustain the fusion reaction, this is known as ignition. The tokamak (a toroidal fusion device) being built in France will be running at such high temperatures that heat distribution is a problem. To prevent future calamity a tokamak run by General Atomics, DIII-D, is running experiments to modify the heat distribution in the divertor region; a narrow area on the floor of the tokamak. The resonant magnetic perturbations (RMPs) from 3D coils are varied to modify the splitting of the divertor strike points in DIII-D. This splitting is imaged in filtered visible and infrared emission to determine the particle and heat flux patterns on the target plates. The observed splitting is compared to vacuum modeling in discharges where a subset of the RMP coils were ramped to shift the divertor footprints from dominantly $n = 3$ to $n = 2$ pattern. The measured splitting has a very similar pattern to the modeled splitting, but is on a scale that is 5 times larger. These results could later be used to determine if the plasma response model can be validated with the measured splitting seen in the camera data. The sensitivity of the modeled splitting depend on details of the 2D equilibrium. The sequence of kinetic equilibria reproduce the time dependence of the measured splitting better than with magnetics only EFITs, indicating that the splitting is sensitive to aspects of the equilibria, such as the bootstrap current and q profile, that vary slowing during the discharge and aren't modeled in a magnetics only EFIT reconstruction. This RMP ramp technique could be used in ITER to spread out the heat flux while avoiding excessive forces on the RMP coils.

Bio: At Oregon State, Abe has spent most of the time doing research. He spent the summer after his sophomore year as an intern at Northwestern University's Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA) in Evanston, IL in astrobiology, where he analyzed mathematical models of theoretical predator-prey systems. A year later, the summer before his junior year, Abe headed down to San Diego to work as an intern at DIII-D, a fusion facility run by General Atomics and funded by the DOE. He used MHD code to model plasma stability, specifically to find conditions that better spread the heat flux in the divertor region. Finally, Abe worked for over two years in Heidi Schellman's particle physics research group, analyzing neutrino-antineutrino data as part of the MINERvA project. In particular, Abe worked on the simulating recoil energies for antineutrino CCQE events. Abe was accepted into the physics Ph.D. program at Stony Brook University in Long Island, New York. He is interested in particle physics and cosmology and is going to be working at CERN the summer before attending graduate school, under Dr. Chang Kee Jung at Stony Brook.

Atilla Varga: Beating modes In proto-stellar disks

Abstract*:* Computational simulations of disks are becoming an important tool to predict the the evolution of protostars and disks to better understand the formation of planets. Past research has shown that the evolution of disks and their protostar can be altered through the interaction between gravity and hydrodynamic instabilities. We perform linear hydrodynamic simulations and analyze characteristic eigenmodes that depend on the geometry, velocity field, and star to disk mass ratio. Many modes arise when the equilibrium system is perturbed and typically the fastest growing mode will dominate the system early in the evolution of the model. On the thresholds between modal types such as Jeans-like modes, P modes and intermediate I modes we observe a phenomenon that resembles beating between two waves. We investigate this hypothesis using Fourier methods to decompose the time history of the perturbed amplitude of the eigenfunction into characteristic frequencies. We show that we can reconstruct the beating waveforms by adding component waves. Analysis shows this beating behavior can be under- stood as a superposition of modes across the threshold of the I- and I+ intermediate modes. I- modes are fast waves characterized by co-rotation near the inner edge of the disk, while I+ plus modes are slow waves characterized by co-rotation near the outer edge of the disk. We show the correlation between modes that arise in the numerical simulation and those constructed in our Fourier analysis. We find that higher order terms in solving the fluid conservation equations are needed in linear simulations to understand this beating behavior. These terms correspond to mode coupling within the disk as shown by the finding Fourier coefficients through the evolution of the simulation. When expanding the modal to evolve non linearly, the we find that in the early non linear simulation, the linear regime resembles early findings. We also see that the higher order $m = 4$ arm mode grows the fastest. The mode coupling found shows that in many regimes, the evolution of the whole disk oscillates with the coupled frequencies. Fourier time history analyses shows that in fact these modes are not due to beating and instead due to the coupling of non linear modes in the early stages of the simulation. This coupling causes the late evolution to be driven unstable through 2 modes instead of one dominant mode when compared to previous studies.

Bio: Attila Varga grew up in Bellevue, Washington wanting to study physics since a young age. He decided to attend Oregon State University and obtain a bachelor's in physics and a minor in mathematics. During his sophomore year, he joined Dr. Kathryn Hadley doing research in computational astrophysics. In the following year he presented research at the Northwest APS meeting. During the summer of his junior year, he was awarded the summer undergraduate research experience (SURE) award to conduct full time research in the summer. Following that, during the winter of his senior year he traveled to Washington D.C to give a talk at the American Astronomical Society winter meeting. After graduating he plans to take a year off and work full time before pursuing a graduate degree in astrophysics.