2015 Red River Valley Undergraduate Physics & Astrophysics Research Symposium

Noon – 5 PM, Friday, May 1st, 2015
Rooms 106 & 211, Witmer Hall
University of North Dakota
Grand Forks, ND 58202

Featuring students from
Department of Physics & Astronomy, Minnesota State University at Moorhead
Department of Physics, North Dakota State University
Department of Physics & Astrophysics, University of North Dakota

Program

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Hosted by

University of North Dakota
Physics & Astrophysics
Grand Forks, ND 58202

Sponsored by

College of Arts & Sciences, University of North Dakota
Office of the Vice-President for Research, University of North Dakota

Organizing committee

Connie Cicha, Robert Czapiewski, Ju Kim, Kanishka Marasinghe, and Paul Noel
Department of Physics & Astrophysics, University of North Dakota
Contact: Kanishka Marasinghe (kanishka.marasinghe@und.edu, 701 777 3560)

Acknowledgements

Drs. Debbie Storrs (Dean, College of Arts & Sciences) and Dr. Barry Milavetz (Interim Vice President for Research & Economic Development) for their generous financial support, Mr. Mark Danes (School of Graduate Studies) for providing poster boards, Dr. Yen Lee Loh for help with the webpage, Drs. Warren Christensen & Sylvio May (North Dakota State University) and Dr. Ananda Shastri (Minnesota State University at Moorhead) for encouraging their students to take part in this event.
ORAL PRESENTATIONS 1 – 3:10 PM, Room 211 Witmer Hall

O-01 Polymer Shapes, Depletion, and Crowding in Polymer-Nanoparticle Mixtures
Wei Kang Lim, Department of Physics, North Dakota State University
Research Supervisor: Dr. Alan Denton

O-02 Modeling GaAs Solar Cell: Python Code for 1-D Homojunction at Equilibrium and Steady State Condition
Iwnetim Abate, Department of Physics & Astronomy
Minnesota State University at Moorhead
Research Supervisor: Dr. Matthew Craig

O-03 Construction of a Low-Cost Scanning Tunneling Microscope
Christopher Pansegrau, Department of Physics and Astrophysics
University of North Dakota
Research Supervisor: Dr. Nuri Oncel

O-04 Extension Of Bohr’s Derivation To Explain Some Spectral Lines Of Helium
Christian Peterson, Department of Physics and Astrophysics
University of North Dakota
Research Supervisor: Dr. William Schwalm

O-05 Screening of Lithium Oxygen Cathode 3D Composite Nano-networks Enabled by M13 Phage Directed Synthesis
Loza Tadesse, Department of Physics & Astronomy
Minnesota State University at Moorhead
Research Supervisor: Dr. Gary Edvenson

O-06 Vortices in Long Josephson Junctions of Multiband Superconductors and their Fractionalization
Benjamin Woods, Department of Physics and Astrophysics
University of North Dakota
Research Supervisor: Dr. Ju Kim

POSTER SESSION 3:15 – 5 PM, Room 106 Witmer Hall

P-01 Polymer Shapes, Depletion, and Crowding in Polymer-Nanoparticle Mixtures
Wei Kang Lim, Department of Physics, North Dakota State University
Research Supervisor: Dr. Alan Denton

P-02 Unlocking the Evolution of Cluster Dwarf Galaxies via the Alignment Effect
Haylee Archer, Gregory Foote, Jaford Burgad, & Cody Rude
Department of Physics and Astrophysics, University of North Dakota
Research Supervisor: Dr. Wayne Barkhouse

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P-03 Two Dimensional Maps of Photoluminescence and Second Harmonic Generation
*Tara Boland, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Xiaodong Xu, University of Washington, Seattle, WA*

P-04 Hysteresis Loops from Vortices in Type 2 Superconductors
*Tara Boland, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Ju Kim*

P-05 The Galaxy Alignment Effect: An Exploration with the Hubble Space Telescope Frontier Fields
*Connor Burgad, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Wayne Barkhouse*

P-06 Optical Conductivity of Magnetoelectric MnTiO$_3$ Single Crystal Probed by Fourier Transform Infrared Spectroscopy
*Yijiang Cai, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Richard Tung*

P-07 UND Frozen Fury Student Launch
*Gregory Foote, Nathan Carlson & Haylee Archer*  
*Department of Physics and Astrophysics, University of North Dakota*  
*Research Supervisor: Dr. Tim Young*

P-08 Atomic Force Microscopy
*Aschalew Chamiso, Department of Physics & Astronomy*  
*Minnesota State University at Moorhead*  
*Research Supervisor: Dr. Ananda Shastri*

P-09 Observational Light Curves for Transiting Extrasolar Planets
*Shelley J. Davis and Geza Kovacs, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Tim Young*

P-10 Molecular Dynamics Simulations of Ionic Microgel Dispersions in the Cell Model
*Mary Hedrick, Department of Physics, North Dakota State University*  
*Research Supervisor: Dr. Alan Denton*
P-11 Determining the Diffusion Coefficient of Water Through Various Void Radii
Andrew Larson, Department of Physics & Astronomy
Minnesota State University at Moorhead
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P-12 Energy considerations of liquid crystals with defects.
Devin Roehrich, Department of Physics and Astrophysics
University of North Dakota
Research Supervisor: Dr. Jorge Vinals, University of Minnesota, Twin Cities

P-13 An Asymmetrically Charged Nanoparticle at the Air-Water Interface
Joseph Roth, Department of Physics, North Dakota State University
Research Supervisor: Dr. Sylvio May

P-14 Particle Swelling and Osmotic Pressure in Nonionic Microgel Dispersions
Matthew Urich, Department of Physics, North Dakota State University
Research Supervisor: Dr. Alan Denton

P-15 Osmotic Pressure and Phase Behavior of Ionic Microgel Dispersions
Tyler Weyer, Department of Physics, North Dakota State University
Research Supervisor: Dr. Alan Denton

P-16 Measuring AC susceptibility for Laser Glasses Doped with Magnetic Ions
Dillon Zins, Department of Physics and Astrophysics
University of North Dakota
Research Supervisor: Dr. Richard Tung
ABSTRACTS

Oral Presentations  1 – 3:10 PM  Room 211 Witmer Hall

Session Chair: Dr. Nuri Oncel, University of North Dakota

O-01 (1:10 – 1:30 PM) Polymer Shapes, Depletion, and Crowding in Polymer-Nanoparticle Mixtures
Wei Kang Lim, Department of Physics, North Dakota State University
Research Supervisor: Dr. Alan Denton

Depletion-induced interactions in polymer-nanoparticle mixtures depend in range and strength on the concentration, size, and shape of the depletants. Crowding by nanoparticles in turn affects shapes of confined polymer coils, e.g., biopolymers in biological cells. By simulating hard-sphere nanoparticles and random-walk polymers, modeled as fluctuating, penetrable ellipsoids, we compute polymer shape distributions and depletion-induced pair potentials. Comparing results with molecular simulations and experiments, we show that polymer asphericity plays an essential role in depletion interactions.

O-02 (1:30 – 1:50 PM) Modeling GaAs Solar Cell: Python Code for 1-D Homojunction at Equilibrium and Steady State Condition
Iwnetim Abate, Department of Physics & Astronomy
Minnesota State University at Moorhead
Research Supervisor: Dr. Matthew Craig

The amount of solar energy that falls on the earth's surface in 40 minutes equals the total annual energy consumption of the entire world. Harvesting solar energy using semiconductor solar cells is the most promising solution for the problem of global warming. Semiconductor solar cells are simply semiconductor diodes that have been carefully designed and constructed to efficiently absorb and convert light energy from the sun into electrical energy. A complete description of the operation of solar cell devices can be obtained by solving the set of semiconductor device equations. In this work, a Python code was developed to solve these equations numerically for one-dimensional Gallium Arsenide (GaAs) homojunction devices that are in steady state and equilibrium conditions. A finite difference method was used to discretize the Poisson's equation. The discretized equations for equilibrium condition were solved iteratively. Based on the solutions, the working principle of solar cell devices were understood and ways to optimize the device performance were suggested.
O-03 (1:50 – 2:10 PM) Construction of a Low-Cost Scanning Tunneling Microscope
Christopher Pansegrau, Department of Physics and Astrophysics
University of North Dakota
Research Supervisor: Dr. Nuri Oncel

The goal of this project was to construct a scanning tunneling microscope on a strict budget, but leave room for future improvement and modification. The microscope operates using 5 major components; power supply, oscilloscope, function generator, control electronics and the STM frame and scan head. The power supply, oscilloscope, and function generator are preexisting equipment from the lab. The control electronics and STM frame and scan head were built from scratch using a design template found online. The approach mechanism is a simple lever using 72 thread per inch screws. The control electronics include a feedback loop to maintain tunneling. The piezo is a disk buzzer that has been sectored in such a way that voltage can be applied to flex the disk to make the tip trace across the surface. The tip motion is governed by the function generator. Tunneling current output is fed into an oscilloscope for visual interaction with the apparatus. Progress on the design is promising, we are relatively certain that the microscope can obtain and maintain tunneling current across the sample plate. An actual sample will be examined in the coming weeks before the control electronics design is finalized. Once we are confident in the performance of the design, the control electronics will be finalized and soldered together on a circuit board.

O-04 (2:10 – 2:30 PM) Extension Of Bohr’s Derivation To Explain Some Spectral Lines Of Helium
Christian Peterson, Department of Physics and Astrophysics
University of North Dakota
Research Supervisor: Dr. William Schwalm

Bohr’s Derivation is extended assuming a natural electron configuration to explain some spectral lines of helium. One result of this is an energy prediction for the unionized helium atom. It is assumed that the two electrons are at 180 degrees apart in a circular orbit. The spectral lines corresponding to of the transition possibilities in the resulting orbitals are calculated where the two electrons make orbital transitions in unison. The first and second ionization are found. Ionization energies based on measurements or standard quantum treatments are seen to agree reasonably well with this simple Bohr-like model.
O-05 (2:30 – 2:50 PM) Screening of Lithium Oxygen Cathode 3D Composite Nano-networks Enabled by M13 Phage Directed Synthesis  
Loza Tadesse, Department of Physics & Astronomy  
Minnesota State University at Moorhead  
Research Supervisor: Dr. Gary Edvenson

Lithium air batteries have captured the world’s attention due to their ultra high ravimetric energy density. There is a need for a cathode that will provide sufficient surface area for the reduction of oxygen and the reverse chemical reactions efficiently. Current research efforts have worked to identify the best materials to complete these tasks, but few direct comparisons exist which decouple material effects from differing morphologies. This study utilizes the M13 phage as a biotemplate in order to create lithium air cathodes of several materials, Ni, Co, Au, Au/Ni, with a comparable, customizable morphology. The porosity, wire thickness and type of metal deposited were varied while keeping the nano network architecture controlled. The use of Co enhanced battery performance 7 fold. Increasing porosity and thinning the nanowires resulted in several fold increased capacity. In addition, SiO2 cathode support along with these modifications gave more than 10% increase in capacity. In general, this is a new biological approach in templation of versatile materials and has a potential to be a less energy consuming approach compared to current synthesis methods, making biotemplated cathodes promising for future clean energy.

O-06 (2:50 – 3:10 PM) Vortices in Long Josephson Junctions of Multiband Superconductors and their Fractionalization  
Benjamin Woods, Department of Physics and Astrophysics  
University of North Dakota  
Research Supervisor: Dr. Ju Kim

The phase dynamics of Long Josephson Junctions of superconductors with multiple condensates, such as MgB2 were investigated. They differ quite substantially from LJJ's of single condensate superconductors. A phase difference across the condensates was introduced in addition to the conventional phase difference across the insulator, which allows the tunneling of Cooper pairs not only across the insulator but also from one superconducting condensate to another in the same superconducting layer. The energetics of the model lead to two coupled differential equations for the phase difference between layers and the phase difference between the two condensates. When the Josephson critical current between the bands is set to zero the phase equations reduce to the single band phase equations as expected. However when the Josephson critical current between the bands is non-zero, soliton solutions still exist. These solitons contain integer multiples of quantized magnetic flux, i.e. Josephson vortices, much like the solutions to single condensate LJJ's. Under certain conditions, however, fractionalization of these vortices can occur and split the magnetic flux quantum between two separate and distinct kinks. Discussion of solutions and implications will be discussed. How fractionalized vortices interact with each other is of great interest. Experimental evidence suggests that they behave slightly different from regular vortices. Results of calculations on how they...
interact will be discussed along with future questions that could lead to further understanding of these interactions. I would like to thank Dr. Ju Kim for his guidance and assistance throughout my research experience.

**POSTER SESSION  3:10 – 5 PM**  
**ROOM 106 WITMER HALL**

**P-01 Polymer Shapes, Depletion, and Crowding in Polymer-Nanoparticle Mixtures**  
*Wei Kang Lim, Department of Physics, North Dakota State University*  
*Research Supervisor: Dr. Alan Denton*

Depletion-induced interactions in polymer-nanoparticle mixtures depend in range and strength on the concentration, size, and shape of the depletants. Crowding by nanoparticles in turn affects shapes of confined polymer coils, e.g., biopolymers in biological cells. By simulating hard-sphere nanoparticles and random-walk polymers, modeled as fluctuating, penetrable ellipsoids, we compute polymer shape distributions and depletion-induced pair potentials. Comparing results with molecular simulations and experiments, we show that polymer asphericity plays an essential role in depletion interactions.

**P-02 Unlocking the Evolution of Cluster Dwarf Galaxies via the Alignment Effect**  
*Haylee Archer, Gregory Foote, Jaford Burgad, & Cody Rude*  
*Department of Physics and Astrophysics, University of North Dakota*  
*Research Supervisor: Dr. Wayne Barkhouse*

The alignment of cluster galaxies is used to determine the impact of the high-density environment on galaxy evolution. We study the alignment of dwarf galaxies by selecting them based on position relative to the cluster red-sequence. We present our results on the alignment of galaxies with; 1) the major axis of the brightest galaxy, 2) the major axis of the cluster, and 3) a radius vector pointing from the cluster center.

**P-03 Two Dimensional Maps of Photoluminescence and Second Harmonic Generation**  
*Tara Boland, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Xiaodong Xu, University of Washington, Seattle, WA*

Technology today demands smaller devices and thus there is a need for smaller components to these future devices. With semiconductors being the backbone of modern technology, there is a need for smaller and smaller semiconducting materials. After the discovery of graphene, other research into monolayer semiconducting materials began. Group IV transition metal dichalcogenides, or MX2 became the interest of research groups because of its properties. The direct band gap in the monolayer limit, along with
its two dimensional nature, make these materials interesting to study for future optoelectronic devices.

**P-04 Hysteresis Loops from Vortices in Type 2 Superconductors**  
*Tara Boland, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Ju Kim*

There are two types of superconducting states, each with their own special properties. A superconductor is a material which below a certain critical temperature exhibits properties such as zero electrical resistance and expulsion of magnetic fields. The complete expulsion of the magnetic field from the inside of a superconductor is known and the Meissner effect. This computational research focuses on Type 2 superconductors, which have two critical fields which mark the transition between the normal and superconducting state. This state transition is unique in the way that it allows for magnetic field lines to penetrate the superconducting material while still maintaining its superconducting state. The penetration of the magnetic field lines is called a magnetic vortex which can dissipate some of the energy carried by the current in a superconductor. I will be simulating vortices induced by a magnetic dipole on the nano-scale which form in a thin film superconductor with given initial conditions for the film. Using that data from the simulation a plot of the hysteresis loop with respect to the magnetic field and the dipole moments will be constructed.

**P-05 The Galaxy Alignment Effect: An Exploration with the Hubble Space Telescope Frontier Fields**  
*Connor Burgad, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Wayne Barkhouse*

Galaxy clusters are the largest known gravitationally bound structures in the universe. Due to their high density and mass, they foster a unique laboratory for studying environmental effects on galaxy evolution. Comparing samples of clusters selected over a large range in redshift allows one to probe greater evolutionary changes in the alignment effect over cosmic time. Numerical simulations have predicted that tidal torques acting on dwarf galaxies as they fall into the cluster environment will cause the major axis of the galaxies to align with their radial position vector. The radial position vector is the line that extends from the center of the cluster through the galaxy's center. I present results from measurements of galaxy alignment using Hubble Space Telescope Frontier Fields data that span a redshift range of $0.31 < z < 0.54$. This sample is combined by scaling each cluster by $r_{200}$, where $r_{200}$ is the radius of a sphere, centered on the cluster, whose average density is 200 times the critical density of the universe. The alignment of the major axis of the dwarf galaxies is measured by fitting a Sérsic function to each galaxy using GALFIT. The quality of each model is visually checked by subtracting the model from the galaxy. The alignment of the major axis of each galaxy is compared with: 1) the
major axis of the brightest cluster galaxy, 2) the major axis of the cluster, and 3) the radially positioned vector. The cluster sample is further broken down into different radial regions.

P-06 Optical Conductivity of Magnetolectric MnTiO₃ Single Crystal Probed by Fourier Transform Infrared Spectroscopy

Yijiang Cai, Department of Physics and Astrophysics
University of North Dakota

Research Supervisor: Dr. Richard Tung

MnTiO₃ is recently discovered to be a magnetolectric, in which the antiferromagnetic (AFM) and the ferroelectric (FE) transitions coincide with each other. Unlike other multiferroics, MnTiO₃ can be naturally found in Earth’s Crust and known to record Earth’s magnetic history. To further understand how the lattice order (FE order) couples to the magnetic order, we carried out a series of optical conductivity analysis on a MnTiO₃ crystal to identify the optical phonon modes and their magnetic-field dependence. The reflectance spectra of a MnTiO₃ crystal are measured by a Fourier Transform Infrared spectrometer at 4K with a magnetic field applied along the c-axis. Optical phonon modes as well as a weak Drude contribution are identified by fitting the reflectance spectra using RefFit. Unfortunately, no significant changes have been observed in the conductivity spectra for magnetic fields up to 18T. It implies that the lattice crystal electric field is either too weak or most likely parallel to the c-axis, thus a crossed electric-magnetic-field configuration cannot be met in the absence of an electric field externally applied in the ab-plane. Nonetheless, we intend to continue on identifying the local lattice distortions that are related to the AFM/FE transitions via temperature dependent studies.

P-07 UND Frozen Fury Student Launch

Gregory Foote, Nathan Carlson & Haylee Archer
Department of Physics and Astrophysics, University of North Dakota
Research Supervisor: Dr. Tim Young

The UND Frozen Fury Rocket Team was challenged by the NASA Student Launch project to design and develop a rocket supported by an autonomous ground system. The requirements included transporting a payload into the rocket from the ground, transitioning the rocket from horizontal to vertical, and inserting the ignition wire, autonomously. The rocket was then launched to a height of 3000 feet and descended safely first after an apogee parachute and then as required by the competition to jettison the payload compartment at 1,000 feet. At that point the rocket was recoverable in two separate parts. The team traveled to Marshall Space Flight Center to compete against 24 other teams across the country. We came in fourth place in altitude with a height of 3107 feet. Our autonomous ground support worked well with one human intervention during the competition. We are awaiting the final score in May.
P-08 Atomic Force Microscopy  
Aschalew Chamiso, Department of Physics & Astronomy  
Minnesota State University at Moorhead  
Research Supervisor: Dr. Ananda Shastri  

The atomic force microscope (AFM) is one kind of scanning probe microscopes (SPM). SPMs are designed to measure local properties, such as height, friction, and magnetism with a probe. It was invented in 1986 at IBM Research Zurich. In contrary to the traditional optical microscopy in which functionality is based on the lenses’ magnification power, AFM doesn't use optical technologies. In our poster we will describe our physic department’s AFM machine and show sample images we took.

P-09 Observational Light Curves for Transiting Extrasolar Planets  
Shelley J. Davis and Geza Kovacs, Department of Physics and Astrophysics  
University of North Dakota  
Research Supervisor: Dr. Tim Young  

We present observational data called a light curve, brightness versus time, of transiting extrasolar planets. The photometric data was collected with the CRUST (Crookston - UND Search Telescope) 16 inch Schmidt-Cassegrain telescope during the period 2012-2014. We used a database of confirmed extrasolar transiting planets from professional search teams to determine the date and time of each transit. The discoveries of the transiting planets are conducted by other groups with planet programs like HAT, WASP, Kepler, Ogle, and CoRot. We picked confirmed transiting planets that had optimal parameters to observe a transit with the CRUST telescope. This included three specific conditions; (1) a transit period that occurred during the hours of one night, (2) had a large decrease in the parent star light due to the planet during the transit, and (3) had a parent star that was bright. The data was reduced with several software programs, including MaximDL, and Excel. In some cases a more extensive analysis using a technique of binning the data was required to sufficiently confirm a decrease in the light from the parent star. The resulting light curves confirmed that small telescopes in urban skies can detect extra-solar transiting planets.

P-10 Molecular Dynamics Simulations of Ionic Microgel Dispersions in the Cell Model  
Mary Hedrick, Department of Physics, North Dakota State University  
Research Supervisor: Dr. Alan Denton  

Ionic microgels are colloidal, cross-linked polyelectrolyte networks with practical applications in the chemical, biomedical, food, and pharmaceutical industries. Permeable to solvent and ions, microgels swell/de-swell in response to changes in temperature and pH. To study the distribution of ions inside and outside of microgels, we perform molecular dynamics simulations of a coarse-grained model, representing a microgel as a
uniformly charged sphere in a spherical cell. We compare resulting ion distributions with predictions of Poisson-Boltzmann theory.

**P-11 Determining the Diffusion Coefficient of Water Through Various Void Radii**  
*Andrew Larson, Department of Physics & Astronomy*  
*Minnesota State University at Moorhead*  
*Research Supervisor: Dr. Ananda Shastri*

Understanding the properties of diffusing liquids is important to understand the delivery of medicine. One can measure diffusion coefficients by using the Terranova nuclear magnetic resonance (NMR) device. The motion of the water molecules in a sample was inhibited by placing spheres of different radii in de-ionized water and the resulting diffusion coefficient measured. The pulsed gradient spin-echo (PGSE) NMR technique was applied to determine the diffusion coefficient of water through the different media.

**P-12 Energy considerations of liquid crystals with defects.**  
*Devin Roehrich, Department of Physics and Astrophysics*  
*University of North Dakota*  
*Research Supervisor: Dr. Jorge Vinals, University of Minnesota, Twin Cities*

Liquid crystals are a state of matter that do not fall into one of the 3 common states of matter. It is a fluid in at least one dimension and behaves as a solid in the others. The average direction of LCs are described by the director. The order parameter is a quantitative way to measure how many of the LC rods are in the same direction. LCs have played a large role in the technology industry and could have applications in other areas. By running simulations we are discovering new things about the energy potentials and stability.

**P-13 An Asymmetrically Charged Nanoparticle at the Air-Water Interface**  
*Joseph Roth, Department of Physics, North Dakota State University*  
*Research Supervisor: Dr. Sylvio May*

Due to the presence of distinct media, charged nanoparticles trapped at a dielectric interface between air and water is a system usually characterized by different charge densities over its surface. In this work we use the non-linear Poisson-Boltzmann equation to describe the electrostatic potential and calculate the effective charge densities in terms of the salt concentration and particle dielectric constant. Even when the entire particle was uncharged, our model allowed to determine a non-zero effective charge on the side exposed to the air.
P-14 Particle Swelling and Osmotic Pressure in Nonionic Microgel Dispersions  
Matthew Urich, Department of Physics, North Dakota State University  
Research Supervisor: Dr. Alan Denton

Microgels are soft colloidal particles, composed of elastic, cross-linked polymer networks, that become swollen in a solvent. The sensitive response of microgel swelling to environmental conditions enables widespread applications, including in the food, pharmaceutical, and petroleum industries. To explore the dependence of microgel size distribution and osmotic pressure on particle density and elasticity, we perform Monte Carlo simulations of microgel dispersions, modeling single-particle swelling by the Flory theory of polymer networks and interparticle interactions by the Hertz theory of elasticity. Our simulation results have potential significance for understanding bulk thermodynamic properties and phase behavior of concentrated microgel dispersions.

P-15 Osmotic Pressure and Phase Behavior of Ionic Microgel Dispersions  
Tyler Weyer, Department of Physics, North Dakota State University  
Research Supervisor: Dr. Alan Denton

Ionic microgels are soft colloidal particles, composed of cross-linked polyelectrolyte networks, that become electrically charged when dispersed in a polar solvent, such as water. Permeability to solvent molecules and ions suits ionic microgels to diverse applications in chemical sensing, drug delivery, and food production. Within a model of ionic microgels that combines elastic and electrostatic interparticle interactions, we develop a Monte Carlo simulation method to compute equilibrium properties of bulk dispersions. We apply our method to explore the dependence of osmotic pressure and thermodynamic phase behavior on particle charge, elasticity, and density. Our results compliment previous molecular dynamics simulation studies, guide the interpretation of experiments, and help to broaden fundamental understanding of how electrostatic and elastic interparticle interactions mutually determine the materials properties of microgel dispersions.

P-16 Measuring AC susceptibility for Laser Glasses Doped with Magnetic Ions  
Dillon Zins, Department of Physics and Astrophysics  
University of North Dakota  
Research Supervisor: Dr. Richard Tung

Silicate or phosphate glasses are doped with laser-active ions (Many of them are magnetic) to make a viable lasing medium for high-power lasers. The emission rates in these laser glasses exhibit an intriguing correlation to the concentration of the laser-active ions, possibly resulting from the coupling between these ions. The interaction between the magnetic laser-active ions may be revealed by measuring the magnetic susceptibility $\chi$ of these laser glasses with various doping concentration and magnetic dopants. To measure the magnetic susceptibility, a sample is subjected to an alternating magnetic field intensity $\mathbf{H}$ generated by applying an alternating current through the primary coil,
while the magnetic susceptibility of the sample is determined by measuring the *electromotive force* $(V_{emf})$ in the secondary coil wound around the sample. Due to the law of magnetic induction, the $V_{emf}$ is proportional to the change of the magnetic field flux, thus the magnitude of the magnetic field flux density $\vec{B}$. By comparing the ratio between $\vec{B}$ and $\vec{H}$, magnetic susceptibility $\chi$ can be evaluated. The project plans to build a magnetic susceptibility probe capable of measuring magnetic susceptibility $\chi$ in the temperature range from 20K to 320K at the frequencies from 100Hz to 100kHz. The interaction between the laser-active ions can be revealed by the critical temperature of the magnetic transitions and by analyzing the temperature/frequency dependence of the magnetic susceptibility $\chi(\omega,T)$.

*Thank you for your participation!*