2017 RED RIVER VALLEY PHYSICS & ASTROPHYSICS UNDERGRADUATE RESEARCH SYMPOSIUM

MINNESOTA STATE UNIVERSITY MOORHEAD

North Dakota State University NDSU

UNIVERSITY OF NORTH DAKOTA

1 – 5 PM, Friday April 21st
Department of Physics & Astrophysics
Rooms 110 & 209
University of North Dakota, Grand Forks, ND

PROGRAM

12:30 – 1:15 PM	Registration, Lunch, & Poster Set Up	Room 110
1:15 – 2:45 PM	Oral Presentations	Room 209
3:00 – 5:00 PM	Poster Presentations	Room 110

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TITLES, PRESENTERS, AND AFFILIATIONS: ORAL PRESENTATIONS

O-01 (1:20 – 1:40 PM) Measuring the Specific Frequency of Globular Clusters around Spiral Galaxies
Nathan Carlson and Gregory Foote
Research Supervisor: Dr. Wayne Barkhouse
Department of Physics & Astrophysics, University of North Dakota

O-02 (1:40 – 2:00 PM) Parallization of Lattice Boltzmann
Jacob Schulze
Research Supervisor: Dr. Alexander Wagner
Department of Physics, North Dakota State University

O-03 (2:05 – 2:25 PM) Simulation of Flux Flow in Quasicrystals
Ashley Heida
Research Supervisor: Dr. Yen Lee Loh
Department of Physics & Astrophysics, University of North Dakota

O-04 (1:25 – 1:45 PM) Structure and Stability of Self-Assembling Nanoparticle Dispersions
Vijay Shah
Research Supervisor: Dr. Alan Denton
Department of Physics, North Dakota State University

TITLES, PRESENTERS, AND AFFILIATIONS: POSTER PRESENTATIONS

P-01 Measuring the Specific Frequency of Globular Clusters around Spiral Galaxies
Nathan Carlson and Gregory Foote
Research Supervisor: Dr. Wayne Barkhouse
Department of Physics & Astrophysics, University of North Dakota

P-02 Structure and Stability of Charged Colloid-Nanoparticle Mixtures
Braden Weight
Research Supervisor: Dr. Alan Denton
Department of Physics, North Dakota State University

Continued on next page.

P-03 Non-covalent functionalization of carbon nanotubes: Controlling Chirality Selectivity via Alkyl Groups of Conjugated Co-Polymers

Braden Weight and Brendan Gifford
Research Supervisor: Dr. Svetlana Kilina, , Department of Chemistry and Biochemistry, North Dakota State University

P-04 Evolution of Star Formation of Dwarf Galaxies within Extragalactic Cluster Substructures

Haylee Archer
Research Supervisor: Dr. Wayne Barkhouse
Department of Physics & Astrophysics, University of North Dakota

P-05 Inferring Gene Regulatory Networks from Time Series Data Using Glass Models

David A. Fehr, Department of Physics & Astrophysics, University of North Dakota
Research Supervisors: Dr. Yen Lee Loh, Department of Physics & Astrophysics, & Dr. Manu Manu, Department of Biology, University of North Dakota

P-06 Applying Different Salt Concentrations in Agar Solution to Improve the Electrocardiogram Signal of Fish

Milka Rahman
Research Supervisor: Dr. Ananda Shastri
Department of Physics & Astronomy, Minnesota State University-Moorhead

P-07 Simulation of Flux Flow in Quasicrystals

Ashley Heida
Research Supervisor: Dr. Yen Lee Loh
Department of Physics & Astrophysics, University of North Dakota

P-08 A simple lattice Boltzmann model for expansion and formation of structure in the early universe

Carly Snell
Research Supervisor: Dr. Alexander Wagner
Department of Physics, North Dakota State University

P-09 An Analysis of Red-Sequence Cluster Spiral Galaxies

Lane Kashur[1] & Wayne Barkhouse[1] & Madina Sultanova[1] & Sandanuwa Kalawila[1] & Haylee Archer[1] & Gregory Foote[1] & Elijah Mathews[1] & Cody Rude[2] & Omar Lopez-Cruz[3]
[1] Department of Physics & Astrophysics University of North Dakota, Grand Forks, ND, [2] MIT Haystack Observatory, Cambridge, MA, [3] INAOE, Mexico
Research Supervisor: Wayne Barkhouse University of North Dakota

P-10 Parallization of Lattice Boltzmann

Jacob Schulze
Research Supervisor: Dr. Alexander Wagner
Department of Physics, North Dakota State University

P-11 Nuclear Magnetic Resonance

Tani Sakurako
Research Supervisor: Dr. Ananda Shastri
Department of Physics & Astronomy, Minnesota State University-Moorhead

P-12 A Novel Method to Determine the Moduli of Single-Wall Carbon Nanotubes

Clay Carufel
Research Supervisor: Dr. Erik Hobbie
Department of Physics, North Dakota State University

P-13 Martens Observatory: UND's Newest and Most Powerful Telescope

Elijah Mathews
Research Supervisor: Dr. Tim Young
Department of Physics & Astrophysics, University of North Dakota

Continued on next page.

ABSTRACTS: ORAL PRESENTATIONS

O-01 (1:20 – 1:40 PM) Measuring the Specific Frequency of Globular Clusters around Spiral Galaxies

Nathan Carlson and Gregory Foote
Research Supervisor: Dr. Wayne Barkhouse
Department of Physics & Astrophysics, University of North Dakota

The specific frequency, SN, of a galaxy is the number of globular clusters per unit galaxy luminosity, this measurement enables comparisons between galaxies in different environments. Our research is to measure the specific frequency of spiral galaxies. To accomplish this, we are examining edge-on spiral galaxies included in the high resolution Hubble Space Telescope archives, measuring the properties of globular clusters around those galaxies, and then estimating the specific frequency of the host spiral galaxy.

O-02 (1:40 – 2:00 PM) Parallization of Lattice Boltzmann

Jacob Schulze
Research Supervisor: Dr. Alexander Wagner
Department of Physics, North Dakota State University

The lattice Boltzmann algorithm is an algorithm that is generally used to simulate fluids. Since collisions in the lattice Boltzmann algorithm occur completely locally, it makes the lattice Boltzmann algorithm a straight-forward algorithm to parallize. This means that the algorithm can be cleanly ran on multiple processors. By running a lattice Boltzmann code on multiple processors, we can run much larger fluid simulations much faster. The goal of my research is to develop a clean and efficient parallel lattice Boltzmann code.

O-03 (2:05 – 2:25 PM) Simulation of Flux Flow in Quasicrystals

Ashley Heida
Research Supervisor: Dr. Yen Lee Loh
Department of Physics & Astrophysics, University of North Dakota

This research project studies an unusual group of materials with two exciting properties: superconductivity and quasicrystallinity. Superconductivity in crystalline materials has been extensively studied and is fairly well understood. However, relatively little research has been conducted to further understand the superconductivity in quasicrystalline materials. The interest in the field is growing rapidly because of the potential ground breaking applications that a superconducting quasicrystal can have. Quasicrystals can be produced commercially or even found in nature, so the idea of a quasicrystal superconductor is not as contrived as one might think. If the project shows that it is indeed possible to enhance flux pinning using a quasiperiodic

background potential, this technology could then be implemented to enhance superconducting wires and magnets. The research will model the quasiperiodic superconducting Josephson junction arrays, represented by time-dependent XY models and Ginzburg-Landau models, using Visual Python and later using C++. It will investigate phase and vortex dynamics under the influence of steady or time- varying magnetic or electric fields or injected currents. The motion of the vortices and antivortices will be tracked and inspected for localized, diffusive or ballistic behavior. The possibility of manipulating vortices using electric and magnetic fields will also be inspected as the physical quantities of interest will be measured, such as the change and vortex currents and conductivities.

O-04 (2:25 – 2:45 PM) Structure and Stability of Self-Assembling Nanoparticle Dispersions

Vijay Shah
Research Supervisor: Dr. Alan Denton
Department of Physics, North Dakota State University

Self-assembly of nanoparticles into a crystalline array (superlattice) is useful for many practical applications, such as raising the efficiency of photovoltaic devices, delivering drugs to the brain, and making food packages more sustainable. By coating nanoparticles with ligand brushes, bulk dispersions can be sterically stabilized against aggregation induced by van der Waals forces. While silicon nanoparticles have many interesting properties, silver nanoparticles are relatively easy to stabilize into equilibrium superlattices. To investigate the dependence of superlattice stability on parameters such as ligand coverage, we perform Monte Carlo simulations to model bulk dispersions of silver nanoparticles governed by an effective pair potential that combines short-range steric and long-range van der Waals forces, as well as the free energy of mixing of the ligands. From particle configurations, we compute radial distribution functions and static structure factors to explore equilibrium structure and phase stability. By investigating the dependence of structure on the van der Waals interactions and ligand coverage, we can characterize the tendency of nanoparticles to self-assemble into ordered arrays or amorphous clusters. Our modeling will eventually be extended to silicon nanoparticles and our results may help to guide the design of future experiments and fabrication of superlattices.

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ABSTRACTS: POSTER PRESENTATIONS

P-01 Measuring the Specific Frequency of Globular Clusters around Spiral Galaxies

Nathan Carlson and Gregory Foote
Research Supervisor: Dr. Wayne Barkhouse
Department of Physics & Astrophysics, University of North Dakota

The specific frequency, SN , of a galaxy is the number of globular clusters per unit galaxy luminosity, this measurement enables comparisons between galaxies in different environments. Our research is to measure the specific frequency of spiral galaxies. To accomplish this, we are examining edge-on spiral galaxies included in the high resolution Hubble Space Telescope archives, measuring the properties of globular clusters around those galaxies, and then estimating the specific frequency of the host spiral galaxy.

P-02 Structure and Stability of Charged Colloid-Nanoparticle Mixtures

Braden Weight
Research Supervisor: Dr. Alan Denton
Department of Physics, North Dakota State University

Colloidal particles can acquire charge through dissociation of counterions in a polar solvent. The resulting electrostatic interactions between particles stabilize the suspension against aggregation due to van der Waals forces and can affect physical properties. We explore the influence of added nanoparticles on structure and phase behavior of charge-stabilized colloidal suspensions. To reduce complexity, we model electrostatic interparticle interactions via effective Yukawa (screened-Coulomb) pair potentials, which implicitly include counterions and salt ions in the Debye screening constant. Within this coarse-grained model, we perform molecular dynamics simulations of mixtures of charged colloids and nanoparticles. Over ranges of parameters (charges, sizes, and concentrations of the two species), we analyze particle configurations to compute radial distribution functions and static structure factors. These structural properties reveal that nanoparticles tend to weaken correlations between colloids, thus destabilizing colloidal crystals. We further show that nanoparticles may be implicitly incorporated into an effective colloid-colloid pair potential to facilitate modeling of complex multicomponent systems and to guide experiments and applications to nanocomposite materials.

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P-03 Non-covalent functionalization of carbon nanotubes: Controlling Chirality Selectivity via Alkyl Groups of Conjugated Co-Polymers

Braden Weight and Brendan Gifford
Research Supervisor: Dr. Svetlana Kilina, , Department of Chemistry and Biochemistry, North Dakota State University

Carbon nanotubes (CNTs) play an important role in nanotechnology, including electronics, chemical sensors, and solar cells. Their electronic and optical properties depend on the size and geometry (chirality) of the nanotube. However, one main concern regarding nanotube application in optoelectronic devices is the difficulty of separating them based upon chirality after synthesis, as all known synthesis methods produce more than one chirality simultaneously. To get around this, one method is the functionalization of the CNTs via non-covalent bonding of co-polymers by wrapping them around the tube. We use force field simulations to explore the effects of various structural manipulations to the co-polymer 9,9-dialkylfluorenyl-2,7-diyl bipyridine (PFO-BPY) to find the preferential mechanisms of selective interactions between the PFO-BPY and CNTs of various chiralities. In particular, we focus on the effect of the branching in alkyl side-groups of PFO-BPY on their binding to the CNT surface. We have observed correlations between the sidegroup structures and their wrapping morphology on the CNT-Polymer interactions. Our calculations demonstrate that the branching in the position closest to the conjugated backboned results in the strongest interaction with all CNT.

P-04 Evolution of Star Formation of Dwarf Galaxies within Extragalactic Cluster Substructures

Haylee Archer
Research Supervisor: Dr. Wayne Barkhouse
Department of Physics & Astrophysics, University of North Dakota

Galaxy clusters form the largest structures in the universe and provide an environment to study galaxy evolution. In particular, dwarf galaxies with low mass are highly susceptible to external influences. Therefore, to understand the star formation history of dwarf galaxies, effects from the environment need to be identified and separated. To address this problem, we examine a sample of galaxies from the Sloan Digital Sky Survey (SDSS). A key part is the characterization of galaxy clusters and cluster substructures, which we address using VariantDBSCAN, an algorithmic technique extending the well-known Density-Based Spatial Clustering of Applications with Noise (DBSCAN). Our approach can vary clustering parameters that each lead to alternative clustering models of galaxy clusters with potentially different shapes and densities. Scientists can thus generate and explore potential evolutionary histories in an semi-automated way.

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P-05 Inferring Gene Regulatory Networks from Time Series Data Using Glass Models
David A. Fehr, Department of Physics & Astrophysics, University of North Dakota
Research Supervisors: Dr. Yen Lee Loh, Department of Physics & Astrophysics, & Dr. Manu Manu, Department of Biology, University of North Dakota

Our goal is to infer genetic regulatory relationships from gene expression time series data, in order to understand, predict, and manipulate the process of cell differentiation. We aim to develop a new reverse engineering methodology using Glass networks, coupled ordinary differential equations that represent gene regulation by the Heaviside function. Our preliminary testing on synthetic data revealed that the accuracy of recovered parameters is limited by the sampling rate of the time series.

P-06 Applying Different Salt Concentrations in Agar Solution to Improve the Electrocardiogram Signal of Fish
Milka Rahman
Research Supervisor: Dr. Ananda Shastri
Department of Physics & Astronomy, Minnesota State University-Moorhead

Studying the heart rates of small fish have important consequences for humans. A non-invasive system for monitoring electrocardiograms (ECG) of small fish is being developed. One problem is the relatively low quality of the ECG signal. The current experimental setup involves silver chloride electrodes coated with agar to reduce the noise arising from water moving over the electrodes. We are trying to improve the signal amplitude of the zebrafish ECG. The purpose of this project is to observe whether or not a better electrical signal is achieved by adding the salt solution in the agar. In order to do this, water level, voltage, and geometry of the agar coating were held constant. Only the concentration of the potassium chloride salt in the solution was changed.

P-07 Simulation of Flux Flow in Quasicrystals
Ashley Heida
Research Supervisor: Dr. Yen Lee Loh
Department of Physics & Astrophysics, University of North Dakota

This research project studies an unusual group of materials with two exciting properties: superconductivity and quasicrystallinity. Superconductivity in crystalline materials has been extensively studied and is fairly well understood. However, relatively little research has been conducted to further understand the superconductivity in quasicrystalline materials. The interest in the field is growing rapidly because of the potential ground breaking applications that a superconducting quasicrystal can have. Quasicrystals can be produced commercially or even found in nature, so the idea of a quasicrystal superconductor is not as contrived as one might think. If the project shows that it is indeed possible to enhance flux pinning using a quasiperiodic background potential, this technology could then be implemented to enhance superconducting wires and magnets. The research will model the quasiperiodic superconducting Josephson junction arrays, represented by time-dependent XY models and Ginzburg-Landau models, using Visual Python and later using C++. It will investigate phase and vortex dynamics under the influence of steady or time- varying magnetic or electric fields or injected currents. The motion of the vortices and antivortices will be tracked and inspected for localized, diffusive or ballistic behavior. The possibility of manipulating vortices using electric and magnetic fields will also be inspected as as the physical quantities of interest will be measured, such as the change and vortex currents and conductivities.

P-08 A simple lattice Boltzmann model for expansion and formation of structure in the early universe

Carly Snell
Research Supervisor: Dr. Alexander Wagner
Department of Physics, North Dakota State University

Much has been written about the apparent difficulty of explaining how an originally homogeneous universe in the early time after the big bang--which because of its small size should have reached thermal equilibrium--could have evolved into a universe that is far out of equilibrium. We show here that this apparent contradiction can be understood by examining a much simpler system where an analogous situation occurs: a non-ideal gas in an expanding volume.
The fluid dynamics of a non-ideal gas can be simulated using a two-dimensional lattice Boltzmann model. In a system initialized with noise, phase separation can be observed over a range of temperatures resulting in a fluid with two distinct densities at equilibrium. Phase separation can also be observed in a fluid in an expanding volume. The phase separation seen under the condition of expanding volume can be compared to the â€œclumpingâ€□ of matter that occurred as the early universe expanded. By implementing a function to decrease overall density as the simulation progresses, the lattice Boltzmann model may be adapted to provide a simple model of expansion and the formation of structure in the early universe.

P-09 An Analysis of Red-Sequence Cluster Spiral Galaxies

Lane Kashur[1] & Wayne Barkhouse[1] & Madina Sultanova[1] & Sandanuwa Kalawila[1] & Haylee Archer[1] & Gregory Foote[1] & Elijah Mathews[1] & Cody Rude[2] & Omar Lopez-Cruz[3]
[1] Department of Physics & Astrophysics University of North Dakota, Grand Forks, ND, [2] MIT Haystack Observatory, Cambridge, MA, [3] INAOE, Mexico
Research Supervisor: Wayne Barkhouse University of North Dakota

For spiral galaxies to acquire the color of elliptical/S0s at a similar luminosity, they must have been stripped of star-forming gas or contain a large fraction of dust. We have compiled a sample of red-sequence spirals and examined their infrared properties as measured by 2MASS, WISE, Spitzer, and Herschel. We compare the dust mass in each red-sequence late-type galaxy with spirals located in the same cluster field but having colors inconsistent with the red-sequence.

P-10 Parallization of Lattice Boltzmann

Jacob Schulze
Research Supervisor: Dr. Alexander Wagner
Department of Physics, North Dakota State University

The lattice Boltzmann algorithm is an algorithm that is generally used to simulate fluids. Since collisions in the lattice Boltzmann algorithm occur completely locally, it makes the lattice Boltzmann algorithm a straight-forward algorithm to parallize. This means that the algorithm can be cleanly ran on multiple processors. By running a lattice Boltzmann code on multiple processors, we can run much larger fluid simulations much faster. The goal of my research is to develop a clean and efficient parallel lattice Boltzmann code.

P-11 Nuclear Magnetic Resonance

Tani Sakurako
Research Supervisor: Dr. Ananda Shastri
Department of Physics & Astronomy, Minnesota State University-Moorhead

In our research, we are working with a technique called nuclear magnetic resonance (NMR). We cannot see this with our eyes, but every nucleus when placed in a magnetic field will start a particular motion called precession. We can detect unknown nuclei in a sample from this rate of precession. For example, the hydrogen nucleus has 42.5759 MHz/T and if we can see this number from the data, we can say hydrogen is present. In this project, NMR data from samples with hydrogen nuclei will be presented and discussed.

P-12 A Novel Method to Determine the Moduli of Single-Wall Carbon Nanotubes

Clay Carufel
Research Supervisor: Dr. Erik Hobbie
Department of Physics, North Dakota State University

Single-wall carbon nanotubes (SWCNTs) are rolled up graphene sheets that are 1 nm in diameter and can range from 100 nm to 100 m in length. SWCNT thin filmâ€™s polymer shape and their Youngâ€™s modulus make them well suited for projects that demand conductivity, flexibility, and durability. The mechanical response of SWCNTs falls short of the behavior that is predicted based on the modulus of a single carbon nanotube and this limits the use of mechanically robust multifunctional thin films. My project will seek to accurately measure the modulus of these thin films and overcome the films earlier mentioned shortcomings by gaining a deeper understanding of the rules that govern thin carbon nanotube films.

P-13 Martens Observatory: UND’s Newest and Most Powerful Telescope

Elijah Mathews
Research Supervisor: Dr. Tim Young
Department of Physics & Astrophysics, University of North Dakota

Martens Observatory and its 0.5m PlaneWave telescope have gone through modifications to reach their full observing potential and to allow remote observing to take place. Software additions have increased the ability to take measurements of celestial objects. Additionally, mechanical devices have been added to streamline continuous remote monitoring of the telescopeâ€™s operations. We present images of galaxies, nebulae, supernovae, and asteroids taken at this observatory. Plans are presented to begin a transient object observing campaign.