

Symposium Day 2012
Tuesday, September 4th, 2012. Room: ABB-102

Introductions

9:00 AM: Dr. David Venus (Chair) & Dr. Paul Higgs (Symposium Day Chair)

9:10 AM: Guidelines for Speakers

Session I Soft Matter – Chair Katharina Fritsch

9:15 AM: Matilda Backholm

Advisor: Dr. Kari Dalnoki-Veress

Title: The micro-mechanical properties of the model organism *C. elegans*

C. elegans, a millimeter-sized nematode, provides an excellent biophysical system for micro-mechanical studies. The undulatory motion exhibited by the worm as it swims or crawls through a medium is ubiquitous in nature at scales from microns to meters, and has been the focus of intense research. However, for a successful description of this form of locomotion, a better knowledge of the material properties as well as the worm's output forces is needed.

Here we present a new experimental assay, with which the material properties and dynamics of *C. elegans* can be directly probed. In this technique, we use the deflection of a very flexible micropipette to measure the bending stiffness of *C. elegans* at all stages of its life cycle. By modelling the worm as a viscoelastic material, we have achieved new insights into its mechanical properties.

Furthermore, the forces involved during the undulatory motion of *C. elegans* have been studied. It is the hope that the direct experimental characterization of this model organism will provide guidance for theoretical treatments of undulatory locomotion in general.

9:35 AM: Mark Ilton

Advisor: Dr. Kari Dalnoki-Veress

Title: Coalescence of Soft Matter in Two Dimensions

Coalescence can be observed in natural systems such as cells, raindrops and galaxies, while also being relevant to industrial processes such as phase dispersion and sintering. In our model system, we are studying the two-dimensional coalescence of diblock copolymers on micron length scales using both optical microscopy and atomic force microscopy. We find that the expected important physical processes (surface tension and viscous dissipation) are not sufficient for describing the dynamics of the coalescence over a wide range in temperatures. The results suggest that inter-layer hopping between the two-dimensional planes of the material is playing an important role in the dynamics at the surface.

9:55 AM: Kyle Pastor

Advisor: Dr. An-Chang Shi

Title: High Curvature Bending of the Lipid Bilayer

The research I focus on has to do with measuring the bending energy of a lipid bilayer membrane. To do this I model the lipids as diblock copolymers with a hydrophilic head groups and hydrophobic tail groups immersed in a homopolymer that is also hydrophilic. Using Self-Consistent Field Theory (SCFT) I am able to stabilize a bilayer and change things like the interactions, size, geometry and radius in order to understand better the bending properties of these structures.

10:15 AM: Tara Power

Advisor: Dr. Nick Provatas

Title: TBA

10:35-10:50 AM: COFFEE BREAK

Session II Theory – Chair Andreas Deschner

10:50 AM: Matthew McCreadie

Advisor: Dr. Itay Yavin

Title: TBA

11:10 AM: David Bazak

Advisor: Dr. Catherine Kallin

Title: A Self-Consistent, Bogoliubov-de Gennes Approach to Quantum Oscillations in the Pi-Striped Superconductor.

Recent observations of quantum oscillations in the physical properties (e.g. specific heat) of the high-Tc cuprate superconductors have come as a major surprise due to the strongly correlated nature of these materials. While the oscillations are typically explained by conventional (weakly correlated) theories, puzzles remain which invite alternative explanations. One such approach is a periodic modulation of the superconducting gap known as the pi-striped superconductor, which reconstructs the Fermi surface and has been shown to give rise to the crucial ingredient for quantum oscillations: Landau levels in the low energy density of states. A natural extension of this work, which will be the focus of my research, is to perform the calculations leading to the Landau levels within the self-consistent Bogoliubov-de Gennes framework, in order to determine the conditions under which a superconductor can support quantum oscillations, and the nature of the supercurrents in such a state.

11:30 AM: Robin Tunley

Advisor: Dr. Itay Yavin

Title: Leptonic Dipole Transitions: A Signature of New Physics?

In this talk I will (re)introduce the notion of a dipole and of a dipole transition in a few familiar settings. I will also briefly discuss the state of lepton flavour in the Standard Model as it presently stands. Finally, I will extend the discussion to the problem I've been tackling: what if some as-yet-unseen dipole transition could cause leptons to change flavour? How would such an interaction manifest itself in experiments? Stay tuned, for all this and more.

11:50 AM: Akbar Safari

Advisor: Dr. Donald Sprung

Title: Some recent developments in WKB quantization condition

The WKB or semi-classical approximation dates back to the earliest days of quantum mechanics. Until 1980 only a handful of potentials were known, for which WKB gave exact bound state energies. That changed with the advent of Supersymmetry and the SWKB approximation, giving large classes of "soluble" models. The exponential potential remains one of the exceptions, but its results are greatly improved by introducing a nonintegral Maslov index in the sense of Friedrich and Trost. This affects mainly the near-threshold energies, and also gives better wave functions than the usual Langer modification. I will outline how this works. [Am. J. Phys. 80 (2012) 734-7]

12:10-1:30PM: LUNCH

Session III Astrophysics – Chair Annie Hou

1:30 PM: Spencer Manwell

Advisor: Dr. Alan Chen

Title: TBA

1:50 PM: Alyssa Cobb

Advisor: Dr. Ralph Pudritz

Title: Nature's starships: Amino acid synthesis, frequency, and their delivery to Earth via meteorites

Understanding the origin of organic molecules on Earth is vital to our understanding of the origins of life. One proposed mechanism for the introduction of organic material to our planet is via meteorite impacts. Meteoritic parent bodies contain organic material and water ice, which, given radionuclide decay in their interiors, cause the ice to melt and the parent bodies to undergo a process called aqueous alteration. An example of this internal chemistry is Strecker synthesis, a process resulting in the production of various amino acids. This talk summarizes recent discoveries regarding amino acid synthesis and concentration data. We present the amino acid concentrations collated from a variety of meteorites (~20) covering a range of meteorite classes. We can use the dependence of amino acid frequency on variables such as temperature and pressure to model Strecker synthesis inside a theoretical parent body. Our modeling software takes a set of chemical species and outputs their relative frequencies based on a minimization of their Gibbs free energies. The goal of this work is to predict and quantify the presence of amino acids on a foreign landscape, say... Mars.

2:10 PM: Alexander Cridland

Advisor: Dr. Ethan Vishniac

Title: Magnetic Helicity Conservation and Astrophysical Dynamos

The existence of magnetic fields in the universe is an undisputed fact. They are seen at all scales, from asteroids in our solar system to entire galaxies. However, the mechanism for their growth and stability still eludes a complete understanding. I will briefly introduce the leading theory for large scale magnetic field growth (Kinematic Dynamo Theory, KDT) as well as the modification that is made to KDT when we consider the conservation of magnetic helicity as the important driver of magnetic field evolution. I will then introduce the Magnetohydrodynamic (MHD) equations and briefly outline our numerical method for solving the equations. I will finally present preliminary results that 1) validate the code and 2) validate predictions made by the modification to KDT and conclude with an outline of the remaining work that will take up my time in the future.

2:30 PM: Corey Howard

Advisor: Dr. Ralph Pudritz

Title: Simulations of radiative feedback from clusters in giant molecular clouds

Star clusters form in dense molecular clouds. Radiation from these newly formed clusters can have a significant impact on their natal molecular cloud through heating and ionization. Recent studies suggest that radiative feedback may be sufficient to disrupt an entire cloud over a short timescale. We use, for the first time, realistic initial conditions for giant molecular clouds obtained through galactic-scale simulations of molecular cloud formation. To examine the degree to which radiative feedback shapes the evolution of our simulated molecular clouds, we use the FLASH hydrodynamics code to simulate cluster formation on an adaptive Eulerian grid coupled with a raytracing scheme to treat radiative transfer. This talk will outline my recent progress in implementing these clouds in FLASH and following their subsequent evolution.

2:50 PM: Benjamin Keller

Advisor: Dr. James Wadsley

Title: Implementing Feedback in Simulated Galaxies

Simulations of disk galaxies produce too many stars and are generally bulge dominated, particularly for more massive galaxies. This issue is fairly independent of the numerical method used, as shown by the recent Aquila galaxy simulation comparison project (Scannapieco et al. 2011) where only ad hoc extreme feedback models (e.g. high-velocity disk-wide galactic winds) were able to reduce the star formation sufficiently. This motivates a closer look at how well we are modeling feedback: processes that suppress star formation and redistribute gas. In this talk, I will discuss progress I have made to produce accurate feedback models for use in galaxy simulations. By looking at high resolution, "zoomed in" simulations, feedback processes can be examined at their natural scale. This will let us bootstrap feedback models for larger, lower resolution simulations that are physically accurate.

3:10 PM: Kevin Sooley

Advisor: Dr. Alison Sills

Title: Stellar Mergers: The Case of V1309 Scorpii

V1309 Scorpii erupted in September of 2008 in a peculiar "red nova" with a brightness increase of 10 magnitudes. Analysis of serendipitous photometry from an unrelated survey of the sky revealed a cool contact binary caught in the act of merging. Excluding supernovae, stellar mergers are the most energetic events on the stellar scale, and lead to as yet poorly understood objects. We can model these mergers using a computational fluid dynamics scheme, such as SPH, but we also require some method of extracting synthetic photometry. I'll introduce monte carlo radiative transfer imaging, which I'm using to produce synthetic photometry.

3:30 PM – 3:50 PM COFFEE BREAK

Session IV Condensed Matter Experiment – Chair Jerod Wagman

3:50 PM: Timothy Munsie

Advisor: Dr. Graeme Luke

Title: From Theory to Experiment: An Exploration of the Low Temperature Phase Space of Cobalt Niobate

In this talk I will describe the growth, characterization and measurement of Cobalt Niobate (CoNb_2O_6). This material shows interesting properties related to the quantum mechanical spins in the single crystal lattice. The spins in the material behave as a 1D Ising-like chain and at low temperatures exhibit an exceptionally long spin relaxation time. The crystal was probed in the magnetic and temperature ranges where antiferromagnetic, incommensurate and spin flip phases could be observed. These properties are investigated using Specific Heat and μSR measurements.

4:10 PM: Robert D'Ortenzio

Advisor: Dr. Graeme Luke

Title: Muon Spin Rotation Studies of the Frustrated Magnet $\text{Yb}_2\text{Ti}_2\text{O}_7$

Magnetic frustration can occur when the geometry of a crystal lattice prevents the minimization of energy of magnetic spins. This can lead to interesting phases, such as the suppression of long range magnetic order. The corner sharing tetrahedral "pyrochlore" structure of $\text{Yb}_2\text{Ti}_2\text{O}_7$ is a great example of such a lattice, and the low temperature phases are a topic of debate, but point to exotic emergent physics.

In this presentation, I will introduce crystal growth of the frustrated system $\text{Yb}_2\text{Ti}_2\text{O}_7$, present SQUID magnetism measurements, specific heat in an applied field up to 9 Tesla, and low temperature Muon Spin Rotation experiments. These measurements will help to elucidate the low temperature phases of this controversial magnetic material.

5:00 PM: BBQ - **TwelvEighty**

Located in Togo Salmon Hall, just down the steps from Union Market, TwelvEighty.