Abstracts:

Vishal Vasan: August 23, 4:00 PM - 5:00 PM, Phillips 332 (Applied Math Seminar)

Title: Some inverse problems related to the theory of water waves

Abstract: I will present a brief introduction to a set of equations governing surface gravity waves. These equations belong to a class of partial differential equations known as free-boundary value problems, i.e., equations posed on an unknown domain. Quite often in applications, we do not have access to the data which leads to a well-posed problem. Instead we have indirect measurements of the quantity of interest. In this talk, I will describe two such problems related to the water-wave equations: (1) obtaining the free surface of the fluid given the pressure measured at the bottom bed, (2) obtaining the shape of the bottom bed given the shape of the free surface of the fluid. I will also discuss, how these problems are approached in the laboratory and the degree of success of our models.

While working in the laboratory, in order to test our theory for the above inverse problems, we required specific wave profiles to be generated by a paddle. This leads to yet another inverse problem, to describe the motion of a paddle to produce a specific wave. In the shallow water regime, this problem has a satisfactory resolution however the same cannot be said for deep water.

Reed Ogrosky: August 26, 10:30 AM - 11:00 AM, Phillips 334

Title: A comparison of modeling approaches for viscous liquid films in cylindrical geometry.

Abstract: I will discuss two classes of models for the evolution of the free surface of a viscous liquid film. Films flowing over a flat surface are often modeled using long-wave asymptotics, where a small ratio of film thickness to wavelength is exploited to derive a single PDE governing the evolution of the free surface. Films which flow over a cylindrical surface such as a tube offer a second natural choice of lengthscale ratio, that of small film thickness to tube radius. Such thin-film models offer simpler nonlinearities and fewer parameters which govern the dynamics, but at the cost of losing some qualitative information about the flow. I will give an overview of a series of long-wave models and their thin-film counterparts developed for the particular problem of a film which coats the interior of a tube and is driven by some combination of gravity, airflow, and capillary forces. A comparison with experiments show the long-wave models are successful in quantitatively capturing the main features of gravity-driven film flow and qualitatively capturing features of air-driven flow; their thin-film counterparts exhibit significant differences in wave amplitude, speed, the nature of the instability and the streamline topology of the underyling fluid flow.

Greg Herschlag: August 26, 11:00 AM - 11:30 AM, Phillips 334

Title: Non-periodic, stochastic molecular dynamic boundary conditions in constant pressure ensembles; from crystal to melt.

Abstract: Nanoscale patterning of materials at scales of less than 20nm remains a challenging problem. Standard techniques, such as lithography, rely on electron and photon beams to shape materials, yet these methods are difficult to employ at the sub 50nm scale. We consider the possibility of employing natural interface instabilities in order to reliably produce desirable structures. Modeling such processes remains a challenging problem; in particular the interfacial properties are heavily dependent on the underlying atomistic structure of the material and the geometry of the interface. We develop non-periodic molecular dynamic boundary conditions, capable of effectively capturing system dynamics in the isothermal-isobaric ensemble; these boundary conditions are viable for a variety of geometries, which show the potential for capturing arbitrary domains in molecular dynamics in both the liquid and solid phase. After exposing the novel boundary conditions and subsequent results, the talk will conclude with future applications in which we plan to develop adaptive MD simulation techniques.

Richard Parker: August 26, 11:30 AM - 12:00 PM, Phillips 334

Title: The Radium EDM Experiment

R.H. Parker, K. Bailey, M.R. Dietrich, J.P. Greene, R.J. Holt, M.R. Kalita, W. Korsch, N. D. Lemke, Z.-T. Lu, P. Mueller, T.P. O'Connor, J. Singh

The observation of a permanent EDM in a non-degenerate system violates T (time) reversal symmetry and hence violates CP (Charge conjugation-Parity) under the CPT theorem. CP violation plays an important role in formulating and constraining theories beyond the Standard Model of Particle Physics, which has provided us with remarkable understanding of the universe but is still considered incomplete. We are searching for the EDM of the 225Ra atom. 225Ra has nuclear spin I=1/2 and its EDM is enhanced due to the increased Schiff moment of its octupole-deformed nucleus. Our experiment involves collecting laser-cooled Ra atoms in a magneto-optical trap (MOT), transporting them with a far off-resonant optical dipole trap (ODT), and transferring the atoms into a standing-wave ODT. We will report our recent observation of the ground state nuclear spin precession of 225Ra in a magnetic field and future plans towards our first measurement of the EDM of 225Ra.

This work is supported by DOE, Office of Nuclear Physics, under contract No. DEAC02-06CH11357 and contract No. DE-FG02-99ER41101

Nick Moore: August 28, 4:00 - 5:00 PM, Phillips 381 (PDE Seminar)

Title: Hybrid analytical/numerical models for fluid-structure problems.

Models that combine analytical and numerical techniques often reap the benefits of both, and I will discuss the use of such models for two fluid-structure problems. First, inspired by natural examples such as landform evolution, I will discuss the erosion of solid bodies by flowing fluids. Table-top experiments with soft-clay bodies eroding in flowing water show the formation of sharp corners and facets, contrary to the notion that erosion is a smoothing process. We develop a model in which an outer flow is coupled to a boundary layer flow which shears away solid material. This model allows us to rationalize the experimental measurements and extend our understanding of the process. Ultimately, we find that the eroding body converges to a terminal form characterized by nearly uniform shear stress, and then shrinks self-similarly in time. Second, I will discuss the motion of bodies through viscoelastic fluids. These fluids store and release elastic energy, leading to characteristically unsteady motion of immersed bodies. As an example, a body settling under gravity experiences an overshoot, in which its speed temporarily exceeds the terminal value. We develop a hybrid analytical/numerical method, valid in the so-called "weak-coupling" limit, that accurately captures the velocity overshoot. Unlike many traditional methods, our method allows efficient and stable computations when the viscoelastic relaxation timescale is long. I will briefly discuss work currently underway in which we apply the weak-coupling method to other viscoelastic-fluid-structure problems.

Rudy Horne: August 29, 10:30 AM-11:30 AM, Chapman 435

Title: Stability and dynamics of solitary waves in AlGaAs waveguide arrays and BEC spinor lattices

In the early 20th century, S. Bose and A. Einstein predicted the existence of a state of matter composed of weakly interacting bosons (integer spin particles). Today, this is known as the Bose-Einstein condensate. The BEC was first experimentally realized in 1995 by E. Cornell and C. Wieman (U. of Colorado at Boulder) and W. Ketterle (MIT).

The focus of this work concerns understanding solitary waves in two different systems: AlGaAS waveguide arrays and in spinor BEC lattice systems. Both the AlGaAs waveguide array and the spinor BEC lattice can be described by two sets of coupled, partial differential equations. In the waveguide array system, we (i) derive solitary wave solutions for the model of interest and (ii) analyze the existence and stability of said solutions via an anti-continuum limit. For the BEC spinor model, we focus on a three-component dynamical lattice model with a mean field nonlinearity. In a similar manner to the waveguide array system, we look at (i) an anti-continuum limit for the model of interest and (ii) the existence and stability of the solitary wave solutions via a perturbative approach.

Sybil Nelson: August 29, 11:30 AM -12:00 PM, Chapman 435

Title: A New Statistical Algorithm for Classifying and Predicting Disease Outcome from Binary and Continuous Predictors and their Interactions

Abstract: The Multidisciplinary Clinical Research Center (MCRC) grant is collecting genetic and environmental data from the SC Gullah population and the Sierra Leone population to identify factors that are associated to Lupus. The data collected is a combination of continuous environmental data and binary SNP data. Traditionally, genetic data is analyzed by searching for associations between genetic factors such as SNPs and disease outcome. Large numbers of genes are analyzed using data mining techniques and significant SNPs are selected. Many techniques, however, do not consider a very particular possibility. Suppose there are genes that do not increase disease risk individually, but only in the presence of an interaction. In this case, these genes may be eliminated as not significant even though, they are an important part of the analysis of disease state. Logic Regression, a tree based classification methodology, is capable of finding these interactions, but cannot be used for continuous covariates. Classification and Regression Tree (CART) is an alternative tree based method that can analyze this type of data but it tends to favor continuous variables over binary. Therefore, a new algorithm called CLogic is developed that can successfully detect interactions of SNPs even in the absence of a main effect as well as incorporate the continuous environmental data without bias.

Joyce Lin: August 30, 4:00 PM - 5:00 PM, Phillips 332 (Applied Math Seminar)

Title: Modeling the Electrical Activity in Cardiac Tissue

Abstract: Electrical stimulation of cardiac cells causes an action potential wave to propagate through myocardial tissue, resulting in muscular contraction and pumping blood through the body. Approximately two thirds of unexpected, sudden cardiac deaths, presumably due to ventricular arrhythmias, occur without recognition of cardiac disease. While conduction failure has been linked to arrhythmia, the major players in conduction have yet to be well established. Additionally, recent experimental studies have shown that ephaptic coupling, or field effects, occurring in microdomains may be another method of communication between cardiac cells, bringing into question the classic understanding that action potential propagation occurs primarily through gap junctions. In this talk, I will introduce the mechanisms behind cardiac conduction, give an overview of previously studied models, and present and discuss results from a new model for the electrical activity in cardiac cells with simplifications that afford more efficient numerical simulation, yet capture complex cellular geometry and spatial inhomogeneities that are critical to ephaptic coupling.