IAM – PIMS
2004-2005 DISTINGUISHED COLLOQUIUM SERIES

The Institute of Applied Mathematics (IAM) and the Pacific Institute of Mathematical Sciences (PIMS) at the University of British Columbia are pleased to announce their 8th Annual Distinguished Colloquium Series.

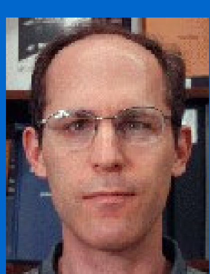
The talks are free and are held in room 301 of the Leonard S. Klinck Building (6356 Agricultural Road, UBC) from 3:00 to 4:00 pm on Mondays. Coffee and snacks are served in room 306, about 20 minutes before the talks.

George Homsy

20 Sep 2004: GEORGE HOMSY – *Dept. of Mechanical and Environmental Engineering, Univ. of California Santa Barbara*

Novel Marangoni Flows

Three recent studies of novel Marangoni flows, i.e., flows caused by tangential stresses due to temperature, compositional, or electrical fields, are described. The first two studies involve gradients of concentration of surfactants arising from variation in the rate of chemical reaction producing them. The effect of in-situ surfactant production on viscous fingering instabilities is studied. Marangoni stresses are found to result in wider fingers, a larger fractal dimension of the pattern, and an increase in displacement efficiency. Next, a surprising phenomenon of spontaneous, self-sustained, chemically driven oscillations at the tip of a drop suspended from a needle is described and connected with the well-known tip-streaming in drops subjected to extensional flows. Plausible physical mechanisms are proposed and mathematical models presented for both phenomena. Finally, theory and experiment are described on internal circulations in drops driven by a combination of translation and tangential electrical stresses. Modulation of the electric field responsible for the latter results in chaotic advection and good mixing within the drop. Theory and experiment are found to be in good agreement.



Raymond Goldstein

25 Oct 2004: RAYMOND GOLDSTEIN – *Dept. of Physics and Inst. for Biomedical Science and Biotechnology, Univ. of Arizona*

A Stirring Tale of Bacterial Swimming and Chemotaxis

Very recent experimental results on collective behavior in bacterial suspensions are described, where the biology of chemotaxis, metabolism and cell-cell signaling is intimately connected to the physics of buoyancy, diffusion, and mixing. These results include the discovery of the "chemotactic Boycott effect" and large-scale coherence characterized by transient, recurring vortex streets and high-speed jets of cooperative swimming. These phenomena generate large Peclet number flows that may fundamentally alter the nature of solute transport in such systems. Certain of these observations can be quantitatively understood through coupled PDEs describing oxygen transport, chemotaxis, and fluid flow. Others have no successful model to date. Some intriguing fluid dynamical studies motivated by these observations are described, including a striking coiling instability of viscous fluid jets.

Andrea Bertozzi

29 Nov 2004: ANDREA BERTOZZI – *Department of Mathematics, University of California at Los Angeles*

Higher-Order PDEs in Image Processing

Nonlinear PDEs are used to model a wide range of phenomena in science and engineering including fluid dynamics, wave propagation, magnetic fields, and biological systems. During the last 15 years PDEs have come to serve a new purpose in engineering – as the basis for algorithm design in image processing. Novel nonlinear PDEs are currently being used to create new algorithms that locally dynamically evolve image pixel values with a global effect being achieved. Applications include edge detection and denoising, image inpainting and reconstruction, super-resolution, compression, and image registration. We discuss a suite of methods based on higher-order equations that are designed to address curvature effects in images.

Roger Brockett

24 Jan 2005: ROGER BROCKETT – *Electrical Engineering and Computer Science, Harvard University*

Dynamical Systems That Do Tricks

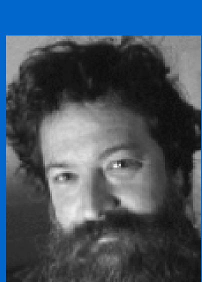
Our ideas about computing are increasingly challenged as more importance is attached to explaining the marvels of biological information processing. At the same time, the mathematical theory of dynamical systems is being revolutionized based on studies of high dimensional integrable systems, on one hand, and low dimensional chaotic ones on the other. In this talk we discuss highly nonlinear input-output systems that perform various calculational tasks in a robust way and link these to biological phenomena. This involves a discussion of input-output versions of the Toda lattice models operating in soliton mode as well as efforts to use distributed representations of geometric quantities, such as those afforded by place cells, to represent numbers in an analog computation.

Adrian Nachman

07 Mar 2005: ADRIAN NACHMAN – *Depts. of Mathematics and Electrical and Computer Engineering, University of Toronto*

Inverse Problems in Medical Imaging

The introduction of X-ray computed tomography in 1972 revolutionized medical imaging, replacing classical qualitative imaging by a quantitative format. Other imaging modalities use acoustic or electromagnetic waves. Mathematically, wave propagation is modeled by partial differential equations, and the class of problems considered consists in determining the coefficients of such an equation (the tissue characteristics), assumed unknown inside the body, from knowledge of its solutions at the surface. These inverse problems turn out to have a rich and beautiful mathematical structure (leading to nonlinear harmonic analysis, as well as to hard questions in differential geometry) and have attracted a considerable amount of research activity. This talk surveys some of the analytic breakthroughs in the field as well as some current open problems.



Raymond Pierrehumbert

28 Mar 2005: RAYMOND PIERREHUMBERT – *Department of Geophysical Sciences, University of Chicago*

Early-Life Crises of Habitable Planets

There are a number of crises that a potentially habitable planet must avoid or surmount if its potential is to be realized. These include the runaway greenhouse, loss of atmosphere by chemical or physical processes, and long-lasting global glaciation. In this lecture I present research on the climate dynamics governing such processes, with particular emphasis on the lessons to be learned from the cases of Early Mars and the Neoproterozoic Snowball Earth.

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