Computational Saturday
May 10, 2008

Project Presentations 18.086 and 18.336
MIT Spring 2008

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1 The Events

The MIT course **18.086: Computational Science and Engineering II** covers numerical methods for initial value problems, the solution of large systems, and optimization and minimum principles.
The MIT course **18.336: Numerical Methods for Partial Differential Equations** provides an advanced introduction to applications and theory of numerical methods for partial differential equations, with emphasis on the fundamental ideas underlying various methods.

In both courses students work on individual projects, applying the concepts learned in the courses to challenging problems. The applications often arise in the students' research field, or the problems are of specific numerical interest. The students and their projects come from a wide variety of areas, ranging from mathematics and computer science to various fields of engineering and planetary sciences.

An central part of the courses are the project presentations. These take place on Saturday, May 10th, between 9:40am and 3:15pm. The presentations are aimed at a general scientific audience, with focus on the numerical solution of physically arising equations. The students and instructors of 18.086 and 18.336 invite you to join the presentations.

More information on the courses, the projects, and this event can be found on the course web pages:
`www-math.mit.edu/18086/`
and
`web.mit.edu/jcnave/www/courses/18.336.htm`

2 Presentation Schedule

Unless otherwise noted, the presentations take place on 05/10/2008.

Time	Speaker 18.086 (2-132)	Speaker 18.336 (2-136)
9:40am	**Junlun Li** Rotated staggered grid	**Huafei Sun** Anisotropic mesh adaptation
10:00am	**Sudhish Kumar Bakku** Waves with surface topography	**XiangDong Liang** Animal migration
10:20am	**Robert Panish** Reentering space shuttle	**Ramis Movassagh** Surface tension driven flow
10:40am	**Haijie Chen** Surface tension driven flow	—break—
11:00am	**Dongfang Bai** Piston secondary motion	**Jae Hyung Kim** Fluttering wing at high Re
11:20am	**Goh Chun Fan** Flow in a changing domain	**Masayuki Yano** High order stabilized FEM
11:40am	**Ishan Barman** Robust multivariate calibration	**WenTing Xiao** Transient wave focusing
12pm–1pm	—break—	—break—
1:00pm	**Tian Fook Kong** Microfluidic switch	**David Henann** Large deformation solid-fluid
1:20pm	**Vernella Vickerman** Membrane chemotatic gradient	**Leon Fay** Electrically small antennas
1:40pm	**Yinchun Wang** Droplet-wall collision	**Ben Druecke** Analysis of inertia-gravity waves
2:00pm	**Hussam Busfar** Locating earthquakes	**Bryce Campbell** Multiphase chemical flows
2:20pm		**Kirki Kofiani** Nonlinear wave-wave interaction
2:40pm		**James Modisette** DG with element size changes
3:00pm		**Laslo Diosady** DG for flows in non-equilibrium
05/13 11:05am		**Alexandre Noll Marques** Unsteady 3D laminar RANS
05/13 11:25am		**Simcha Singer** Particle combustion/gasification
05/14 1:05pm	**Legena Henry** Viscous boundary layer	
05/14 1:25pm	**Robert Legge** Flow with porosity gradient	

3 Titles and Abstracts

Speakers in alphabetical order.

Dongfang Bai: Solving piston secondary motion of internal combustion engines(ICE)

This project simulates piston secondary motion of ICEs. An implicit control volume method is used to solve the pressure distribution in the oil film between cylinder and piston, which has taken into consideration the cavitation phenomenon. A Newton's method is used to solve the piston skirt deformation due to the generated pressure.

Sudhish Kumar Bakku: Modeling elastic wave propagation in a layered medium with surface topography

Elastic wave propagation is modeled in finite differences by a staggered grid formulation. The accuracy of the method and stability are discussed. In the model, a finite region is considered for wave propagation. Whereas, in real life situation, we have semi-infinite space. The reflections at the boundaries would over shadow the real signals. To prevent this, energy is absorbed at the boundary by using PML (Perfectly Matching Layer). Also, we would address the issue of modeling topography at the surface by multi-grid method.

Ishan Barman: Understanding constrained regularization to develop robust multivariate calibration schemes

Multivariate calibration is a valuable analytical tool for extracting constituent concentrations in complex chemical systems that exhibit linear response. Multivariate techniques are particularly well suited to analysis of spectral data because information about all of the analytes can be collected simultaneously at many wavelengths. In this talk, a hybrid multivariate calibration method is presented to improve the robustness of the existing calibration methodologies. Its utility is demonstrated on the basis of experimental Raman spectra. In this new method, multivariate calibration is treated as an inverse problem in which an optimal balance between model complexity and noise rejection is achieved, using Tychonov regularization, with the inclusion of prior information in the form of a spectral constraint.

Hussam Busfar: Locating earthquakes and minimizing the error

Locating earthquakes is a challenging problem especially if these earthquakes are weak and the seismic network is sparse. In my project, I generate synthetic earthquakes knowing their location and the velocity structure of the subsurface. Then, I try the inverse problem and examine how accurate we can locate those earthquakes and the velocity structure knowing only the geometry of the seismic network and the first P-wave arrival time.

Bryce Campbell: Numerical simulation of instabilities in multiphase chemical flows

Haijie Chen: Surface Tension Driven Flow Field and Free Surface Evolution

The project solves the problem of free surface evolution of surface tension driven flow. Three different numerical schemes, including the explicit, implicit and the semi implicit of finite difference method are implemented and their merit and demerit are evaluated. In the end, some preliminary results of the problem have been achieved and analyzed.

Laslo Diosady: DG discretization of flows in chemical and thermal non equilibrium

Ben Druecke: Spectral analysis of inertia-gravity waves

Goh Chun Fan: Fluid flow in a changing domain

Leon Fay: Simulating electrically small antennas

David Henann: An Eulerian approach for large deformation elasticity: application to solid-Fluid interaction

Legena Henry: A simulation of a viscous boundary layer upon the introduction of vortices

A simulation of the response of a viscous, incompressible boundary layer to an impulsive change in bottom porosity. An observation of the vorticity introduced by the impulsive change (simulated receptivity).

Jae Hyung Kim: 2D simulation of a fluttering wing at high Re

Kirki Kofiani: Numerical simulation of non-linear wave-wave interaction

Tian Fook Kong: Modeling a microfluidic switch based on hydrodynamic spreading

Robert S. Legge Jr: Fluid flow through porous media with different porosity gradients

Finite differences was used to estimate fluid transport properties through porous metal in relation to electrospray thrusters. The simulation used the Darcy law approximation to gather data about macroscopic fluid transport. Studies were performed to see how much current could be driven to the site of ion emission for different emitter geometry and material porosity, given an operational electrostatic source pressure. In addition, results were obtained with the addition of a material porosity gradient.

Junlun Li: Coupling of focal mechanism with finite difference wave propagation in a rotated staggered grid

In the presentation, I will talk about rotated staggered grid, a new staggered grid scheme which can avoid the problems the traditional staggered grid has when encounters high contrast medium, say rock and water. Furthermore, I would couple source mechanism into this numerical scheme to simulate complex seismic generation and propagation.

XiangDong Liang: Dynamics of animal migrations in group

Alexandre Noll Marques: Time-Accurate unsteady solution of 3D laminar RANS equations using implicit algorithms

James Modisette: DG discretization for meshes with rapid element size changes

Ramis Movassagh: 2D model of surface tension driven incompressible flows

Robert Panish: Exploration of shock formation for a reentering space shuttle

NASA's space shuttle orbiter enters the Earth's atmosphere at Mach 25, 17,500 MPH. Friction with the thickening atmosphere causes substantial heating of the vehicle. Shock waves form in the compressible flow, substantially altering the temperatures experienced by the orbiter. Accurate prediction of the shock locations is crucial for designing the thermal protection system. A finite difference method for calculating the 2D steady state flow is presented and the results are compared to experimental data published by NASA. Based on the actual shuttle thermal protection system, some estimates are made about the range of safe entry speeds and attitudes.

Simcha Singer: Simulation of combustion/gasification of a porous coal char particle

Huafei Sun: 2D anisotropic mesh adaptation using error estimates of functional output

Vernella Vickerman: Membrane dynamics during stimulation with chemotatic gradients

Motile cells have an internal machinery that helps to determine the direction in which it should move. Additional external probes are however necessary to communicate information about the surrounding environment to the internal *brain*. This external sensing mechanism is facilitated by localized membrane movement as well being part of its integrated response to a given stimulus. This project explores the localized response of a *test cell* subjected to gradients in nutrient concentration by implementing a level-set method.

Yinchun Wang: Simulation of simple droplet-wall collision

In this project, the collision of a single droplet with a wall is simulated by a finite difference method. The droplet interface evolution is controlled by a level-set function. Different behaviors of the droplet are observed.

Masayuki Yano: Analysis of high order stabilized FEM for advection-diffusion equation

WenTing Xiao: A 2D Riemann Solver for a transient wave focusing problem