NUS and NTU Joint Workshop on Industrial and Applied Mathematics

5 December 2008

Programme of talks, 5 December (Friday)

At Department of Mathematics, Nanyang Technological University (NTU) - Executive Classroom 1 (SPMS-MAS-03-06)

9:00-9:40 Talk by Mario Primicerio (Florence)

9:40-10:20 Talk by Li-Lian Wang (NTU)

10:20-10:40 Tea Break

10:40-11:20 Talk by Alistair Fitt (Southampton)

11:20-12:00 Talk by Xue-Cheng Tai (NTU)

At S14 #03-10, Department of Mathematics, National University of Singapore (NUS)

2:30-3:10 Talk by Kim-Chuan Toh (NUS)

3:10-3:50 Talk by Ian Sloan (UNSW)

3:50-4:10 Tea Break

4:10-4:50 Talk by Peter Pang (NUS)

4:50-5:30 Talk by Rolf Jeltsch (ETH Zurich)

6:30 Dinner, NUS Guild House

The title and abstract of the talks are as follows:

Talk by Mario Primicerio
Title: Evolution of criminality in a socially-structured population

Abstract: We consider a closed population structured in social classes assuming that social promotion and relegation depends on the total wealth of the population. We then consider the model in presence of a particular class of "criminals" (burglars) and of "guards". The stability of the criminal-free solution is discussed in particular cases and a special example is studied to compare different means of controlling criminality".

Talk by Li-Lian Wang
Title: Efficient High-order Methods for Scattering and High-dimensional Problems

Abstract: Over the years, high-order methods have gained phenomenal popularity among computational scientists and engineers because of their superior accuracy

and efficiency when properly implemented. In this talk, we will first present fast and stable spectral-Galerkin methods for prototypical boundary value problems using generalized Jacobi polynomials as basis functions, which enjoy computational complexity comparable to finite-element and finite difference methods, yet capable of providing more accurate solutions with a smaller number of unknowns. Particular applications to high-order PDEs, such as fifth-order KdV equations, will be discussed. Secondly, we will introduce efficient high-order methods for time harmonic wave scatterings with high wave numbers, which integrate a domain truncation technique using Dirichlet-to-Neumann (DtN) map, a boundary perturbation method, and fast spectral-Galerkin solvers. In the final part of the talk, we will present some recent results on spectral-Galerkin methods using hyperbolic cross and sparse grids for high-dimensional PDEs. The theoretical results in the newly established framework of Jacobi-weighted Sobolev and Korobov spaces will be reported.

Talk by Alistair Fitt
Title: Flow and deformation in human eyes

Abstract: This talk will address a range of fluid mechanics and elasticity problems concerned with the human eye. Each problem that is considered will have direct relevance to illnesses, adverse conditions or medical procedures that are commonly encountered in hospital eye units. The main mathematical tools involved will be linear elasticity, nonlinear ODEs, Stokes flow and asymptotic analysis. Problems that are discussed will include flow in the anterior chamber (- the prevention of hyphemas and hypopyons), the process of tonometry to measure intraocular pressure in scleral buckled eyes, the prediction of open angle glaucoma resulting from trabecular meshwork blockage of flow into Schlemm's canal and the evolution of a macular tear into a rhegmatogeneous retinal detachment.

Talk by Xue-Cheng Tai
Title: A robust finite element method for Darcy–Stokes flow

Abstract: Finite element methods for a family of systems of singular perturbation problems of a saddle point structure are discussed. The system is approximately a linear Stokes problem when the perturbation parameter is large, while it degenerates to a mixed formulation of Poisson’s equation as the perturbation parameter tends to zero. It is established, basically by numerical experiments, that most of the proposed finite element methods for Stokes problem or the mixed Poisson’s system are not well behaved uniformly in the perturbation parameter. This is used as the motivation for introducing a new “robust” finite element which exhibits this property. Theoretical analysis and numerical experiments will be given to show that the new element is robust for the perturbation parameter in all the ranges. This works has been done jointly with K. Mardal and R. Winther.

Talk by Kim-Chuan Toh
Title: An augmented Lagrangian method for regularized semidefinite least squares problems

Abstract: We consider a Newton-CG augmented Lagrangian method for solving regularized semidefinite least squares (SDLS) problems from the perspective of inexact semismooth Newton methods. Numerical experiments on a variety of large scale SDLS problems with matrix dimensions up to 2000 show that the proposed method is robust and efficient.

Talk by Ian Sloan
Title: High dimensional challenges for computational mathematics

Abstract: Richard Bellman coined the phrase “the curse of dimensionality” to describe the extraordinarily rapid increase in the difficulty of most problems as the number of variables increases. A typical problem is numerical multiple integration. It is clear that the cost of every integration formula of product type rises exponentially with the number of dimensions. Nevertheless, problems with hundreds or even thousands of variables do arise, and are now being tackled successfully. In this talk I will touch briefly on recent advances in understanding and constructing high dimensional integration rules, but much of the focus will be on applications, in diverse fields such as mathematical finance, linear models in statistics, and flow through porous media. A general theme is that high-dimensional problems present an enduring challenge for numerical analysis.

Talk by Peter Pang
Title: Prey-Predator Model with Stage Structure

Abstract: In this talk, we describe a diffusive prey-predator model with stage structure for the predator. Taking into account the role the immature predator plays in the ecosystem, this model results in a strongly coupled nonlinear reaction diffusion system which includes a cross diffusion term. We will discuss the biological and mathematical relevance of this model, and prove the emergence of stationary patterns for the PDE system.

Talk by Rolf Jeltsch
Title: Numerical Simulation of Compressible Magnetohydrodynamic Plasma Flow in a Curcuit Breaker

Abstract: The main function of a circuit breaker is to switch off the electric current safely, in case of fault current. A mechanical force separates the contacts, and an arc starts to burn between the two contacts. This plasma is described by the resistive Magnetohydrodynamics (MHD) equations. The emphasis is on very high currents (10kA-200kA) and relatively high conductivity. Radiation is incorporated by adding a Stefan's radiation. To simulate the plasma in the arc the Nektar code developed by Brown University is adapted and extended. It is based on the Discontinuous Galerkin (DG) methods allowing for triangular or quadrilateral meshes in 2d and hexagonal or tetrahedral meshes in 3d. GID is used for mesh generation. The code is extended to include Runge-Kutta time stepping, various accurate Riemann solvers for MHD, slope limiters and SF_6 gas data. It operates on both serial and parallel computers with arbitrary number of processors.The suitability of this Runge-Kutta Discontinuous Galerkin (RKDG) methods is analysed. In particular different numerical fluxes, different Riemann solvers and limiters, low and high order approximations on smooth ad non-smooth solutions are investigated. Numerical results are given. This work has been performed by Patrick Huguenot and Harish Kumar in their Ph.D. thesis and by Vincent Wheatley.