The Tenth semi-annual Israeli Workshop on Applied and Computational Mathematics

Organizer: Gadi Fibich

We are very happy to host the 10th semi-annual meeting here at Tel Aviv University. We have an excellent program on diverse aspects of applied mathematics, and we hope you will join us at this meeting.

Date: Tuesday, December 30th, 2008

Location: Melamed auditorium, Shenkar building, Tel Aviv University
Shenkar building is 3 minute walk from the Schreiber building, see
www.math.tau.ac.il/school/access.html

Registration Participation in the workshop is free, but you are asked to register by email to fibich@tau.ac.il by **December 24**, in order to get a name-tag and a lunch coupon.

Parking: If you need a parking permit, send an email with your full name and car license plate number to fibich@tau.ac.il **by December 24**

Support: We thank the School of Mathematical Sciences at Tel Aviv University for its generous support

Program:

9:00 - 9:30	Registration and Opening	
9:30 - 10:00	Sergei Kuksin (Ecole Polytechnique Palaiseau)	On non-autonomous Schrödinger equation on d-torus
10:00 - 10:30	Chen Greif (UBC)	Primal Schur Complement Preconditioners for Saddle Point Linear Systems
10:30 - 11:30	Coffee break	
11:30 - 12:00	David Levin (Tel Aviv University)	Green Coordinates
12:00 - 12:30	Daniel Shapira (BGU)	Zooming in: self emergence of movements in new product growth
12:30 - 14:15	Lunch break	
14:15 - 14:45	Ilan Degani (University of Bergen)	Control and efficient simulation of quantum dynamics
14:45 - 15:15	Edriss Titi (Weizmann and UC Irvine)	Alpha Sub-grid Scale Models of Turbulence and Inviscid Regularization
15:15 - 15:30	Posters oral presentation	
15:30 - 16:00	Coffee break and poster session	
16:00 16:30	Uri Ascher (UBC)	Surprising Computations
16:30 - 17:00	Martin Frass (Technion)	Singular Schrödinger Operators and Criticality

Poster presentations

Nir Gavish (Tel Aviv University)	Predicting the filamentation of high-power beams and pulses without numerical integration: A nonlinear Geometrical Optics method
Chen Sagiv (Image Processing & Math More)	Do Uncertainty Minimizers attain minimal uncertainty?
Yana Nec (Technion)	Pattern formation in systems with anomalous diffusion
Roy Malka (Weizmann)	On Bacterial Dynamics
Jasmine Linshiz (Weizmann)	Alpha regularization of the 2D vortex sheet motion
Shaul Tayeb (Technion)	Optimal Reduction of Dynamical Subsystem in the Presesnce of Rayleigh Damping

List of Abstracts:

On non-autonomous Schrödinger equation on d-torus
Sergei Kuksin (Ecole Polytechnique Palaiseau)

In my talk I will present recent results on linear Shroedinger equations on d-torus with time-quasiperiodic potentials, obtained jointly with H.Eliasson. I will also discuss some related results on non-autonomous Scroedinger equations with smooth potentials.

Primal Schur Complement Preconditioners for Saddle Point Linear Systems
Chen Greif (UBC)

Saddle point linear systems arise in a variety of constrained PDE and optimization problems. When these systems are very large and sparse, iterative methods must be used to compute a solution. A challenge here is to derive and apply preconditioners that exploit the properties and the structure of the given discrete operators, and yield fast convergence while imposing reasonable storage requirements. In this talk I will provide an overview of block preconditioners and discuss their spectral properties, bounds on convergence, and computational qualities. We will look at a variety of such techniques and focus on primal Schur complement-based approaches and augmentation techniques.

Green Coordinates
David Levin (Tel Aviv University)

We introduce Green Coordinates for closed polyhedral cages. The coordinates are motivated by Green's third integral identity and respect both the vertices position and faces orientation of the cage. We show that Green Coordinates lead to space deformations with a shape-preserving property. In particular, in 2D they induce conformal mappings, and extend naturally to quasi-conformal mappings in 3D. In both cases we derive closed-form expressions for the coordinates, yielding a simple and fast algorithm for cage-based space deformation. We compare the performance of Green Coordinates with those of Mean Value Coordinates and Harmonic Coordinates and show that the advantage of the shape-preserving property is not achieved at the expense of speed or simplicity. We also show that the new coordinates extend the mapping in a natural analytic manner to the exterior of the cage, allowing the employment of partial cages.

(A joint work with Yaron Lipman and Daniel Cohen-Or)

Zooming in: self emergence of movements in new product growth
Daniel Shapira (BGU)

In this paper, we propose an individual-level approach to diffusion and growth models. By “zooming in”, we refer to the unit of analysis, which is a single consumer (instead of segments or markets) and the use of granular sales data (daily) instead of smoothed (e.g., annual) data as is more commonly used in the literature. By analyzing the high volatility of daily data, we show how changes in sales patterns can self-emerge as a direct consequence of the stochastic nature of the process. Our contention is that the fluctuations observed in more granular data are not noise, but rather consist of accurate measurement and contain valuable information. By stepping into the noise-like data and treating it as information, we generated better short-term predictions even at very early stages of the penetration process. Using a Kalman-Filter-based tracker, we demonstrate how movements can be traced and how predictions can be significantly improved. We propose that for such tasks, daily data with high volatility offer more insights than do smoothed annual data.

Control and efficient simulation of quantum dynamics
Ilan Degani (University of Bergen)

We briefly overview some examples of quantum control problems appearing in different fields, ranging from existing technology (NMR/MRI) to research (control of nano devices, laser control of molecules). In all these examples the same type of problem emerges: to control a bilinear flow on a unitary (or orthogonal) group with piecewise constant controls. We review the existing optimal control approach, and point out some of its problems. Namely, the standard extremal control equations can not generally hold for piecewise constant controls; the only structural requirement from the controls is to have small L_2 norm. We then discuss our approach which derives the correct extremal equations, and which can prefer controls with desired structure. Particularly, we are able to compute optimal controls belonging to a desired subspace of control functions. Thus our methods may hopefuly be useful for computing controls which are producible by realistic laboratory lasers.

Time permitting, we shall also discuss an efficient discretization scheme for Schrodinger equations based on Monge-Ampere PDEs. We compute coordinate transformations, from a computational domain to the physical one, which can zoom in or out of desired regions. In this way computational effort is concentrated where it is needed.

(The work on control is joint with Antonella Zanna)

1) I. Degani, A. Zanna, Lene Saelen, and Raymond Nepstad, Quantum control with piecewise constant control functions, submitted (2008).

2) I. Degani, Monge-Ampere grids and the multidimensional mapped Fourier method, journal of chemical physics, 128 (2008) 164108.

Alpha Sub-grid Scale Models of Turbulence and Inviscid Regularization
Edriss Titi (Weizmann and UC Irvine)

In recent years many analytical sub-grid scale models of turbulence were introduced based on the Navier--Stokes-alpha model (also known as a viscous Camassa--Holm equations or the Lagrangian Averaged Navier--Stokes-alpha (LANS-alpha)). Some of these are the Leray-alpha, the modified Leray-alpha, the simplified Bardina-alpha and the Clark-alpha models. In this talk I will show the global well-posedness of these models and provide estimates for the dimension of their global attractors, and relate these estimates to the relevant physical parameters. Furthermore, I will show that up to certain wave number in the inertial range the energy power spectra of these models obey the Kolmogorov -5/3 power law, however, for the rest the inertial range the energy spectra are much steeper.

In addition, I will show that by using these alpha models as closure models to the Reynolds averaged equations of the Navier--Stokes one gets very good agreement with empirical and numerical data of turbulent flows for a wide range of huge Reynolds numbers in infinite pipes and channels.

It will also be observed that, unlike the three-dimensional Euler equations and other inviscid alpha models, the inviscid simplified Bardina model has global regular solutions for all initial data. Inspired by this observation I will introduce new inviscid regularizing schemes for the three-dimensional Euler, Navier—Stokes and MHD equations, which does not require, in the viscous case, any additional boundary conditions. This same kind of inviscid regularization is also used to regularize the Surface Quasi-Geostrophic model.

Finally, and based on the alpha regularization I will present, if time allows, new approximation of vortex sheets dynamics.

Surprising Computations
Uri Ascher (UBC)

Computer simulations for differential equations (DEs) often require complex numerical methods. It is important and often difficult to devise efficient methods for such purposes and to prove their properties. The resulting computations usually produce expected results, at least qualitatively, which in itself does not diminish the importance of the numerical methods.

Occasionally, however, one comes across a (correct) computation that yields surprising results. In the process of writing a textbook on numerical methods for time dependent DEs I have encountered some such, and this talk describes several instances including solving Hamiltonian systems, KdV and NLS, and applying WENO methods for nonlinear conservation laws. What can be qualified as ``surprising'' is of course a subjective matter, nonetheless the combined effect of this talk hopefully sheds light on using marginally stable methods for solving marginally stable problems.

On critical Schrödinger operators with a singular surface interaction
Martin Frass (Technion)

In the first part we will use the solvability of singular Schrödinger operators to demonstrate several topics from the theory of positive solutions. Especially its relation to criticality. In the second we will use the above theory to show that for a critical interaction on the sphere with a constant coupling, any small area preserving radial deformation gives rise to isolated eigenvalue.