Programme & Abstracts

SANUM 2011

The 35th Annual South African Symposium on Numerical and Applied Mathematics

23, 24 and 25 March

Hosted by the
Department of Mathematical Sciences
Stellenbosch University
South Africa

Welcome to SANUM!

Registration takes place on Wednesday 23 March from 08:15 to 08:50 in the foyer of the Van der Sterr (mathematics) building, located behind the Neelsie student centre between Victoria and Merriman roads.

On the cover: Panoramic view of Stellenbosch from Papegaaiberg. Photo by Francois Malan.

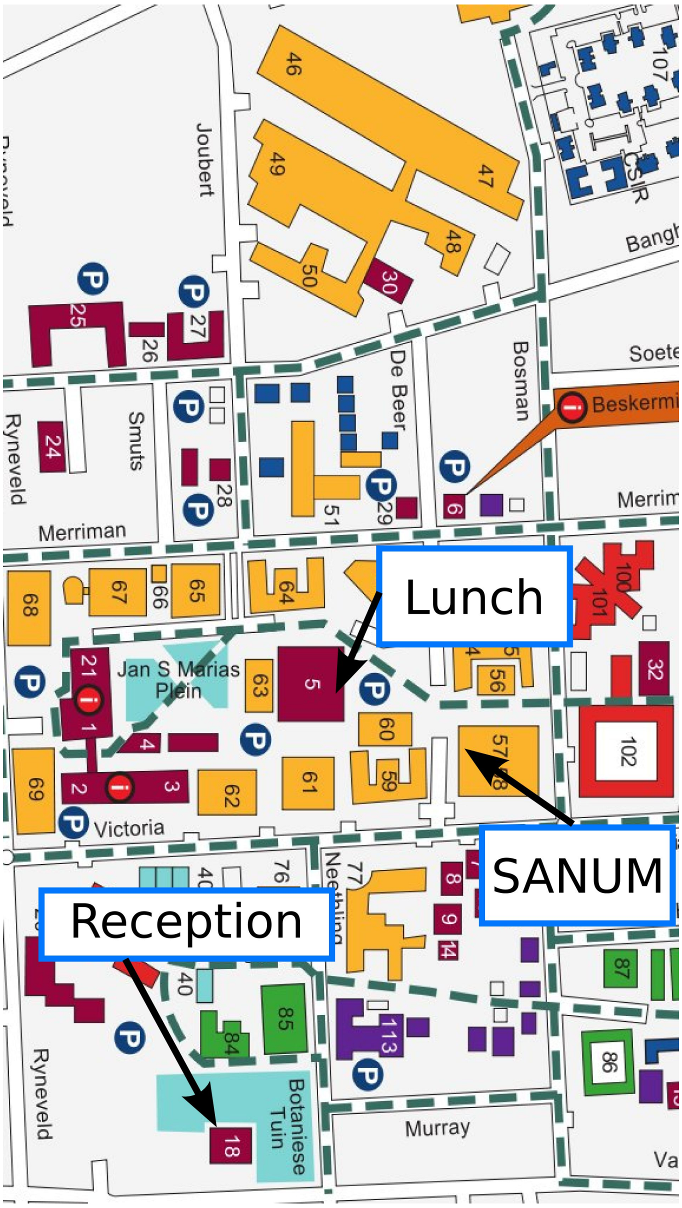
Internet Access, Reception, Lunches

Internet access is available on four computers in room 3013 (third floor).

> To enable internet access, run the *NXInetkey* program from the desktop.
>
> Login: twbesoekers
> Password: Sanumconf11
>
> We are charged per megabyte, so please conserve bandwidth. If you are the last person to leave, kindly lock the room.

Please join us for a **welcoming barbecue** (or *braai,* as we call it in South Africa) on Wednesday evening 19:00 at the botanical gardens.

Lunch is served daily at *Die Bloukamer* restaurant on the top floor of the Neelsie student centre.

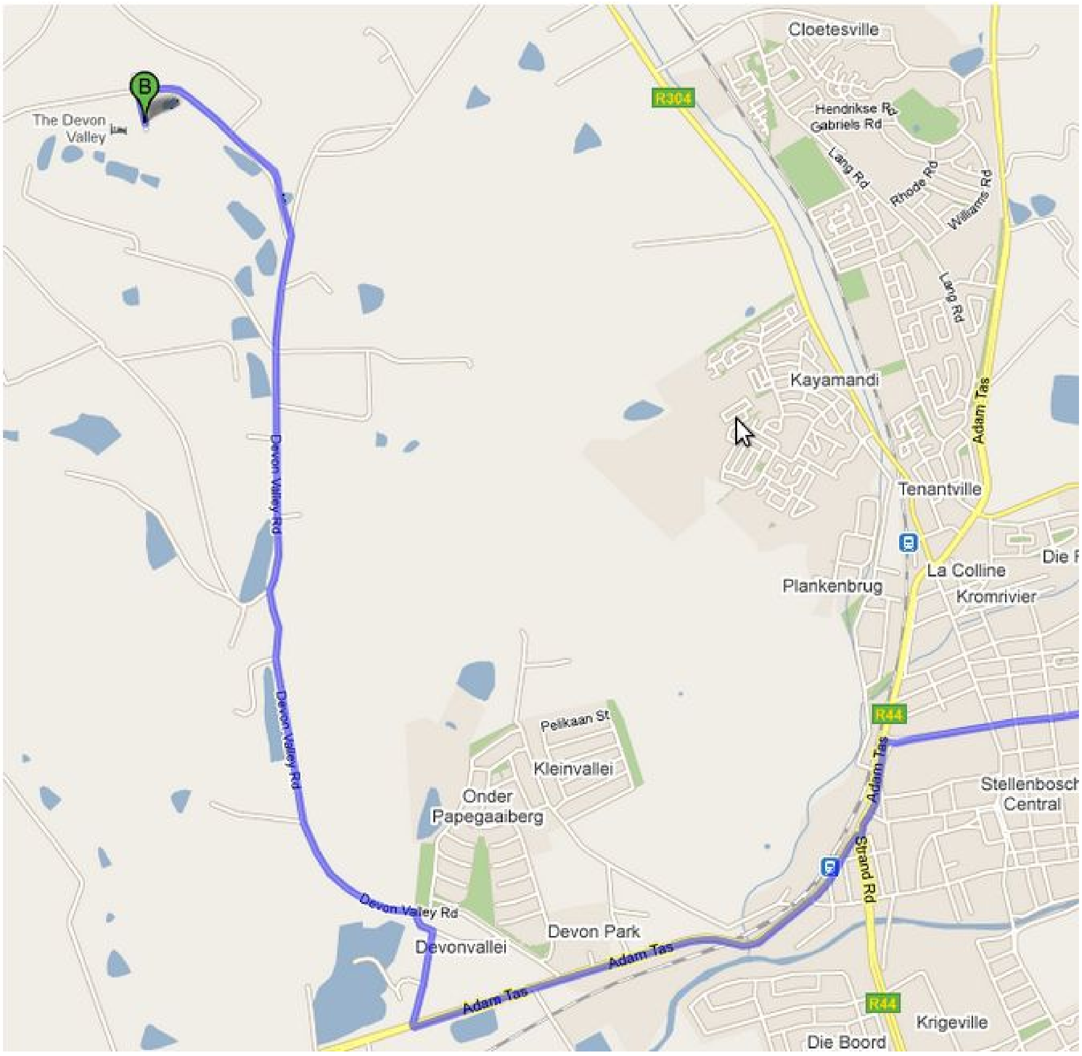


Conference Dinner (Thursday evening)

The conference dinner is held on Thursday evening at 19:00 at the Clos Malverne wine estate. Please meet in front of the conference venue at *18:45 if you require transport*.

Directions to GPS coordinates: S33°54.67 E18°48.810

- Drive down the Adam Tas road (the one that leads to *Spier)* towards Cape Town.
- Drive over Adam Tas bridge, and cross the traffic light with the big white arches on your left.
- A wood-mill appears on the right. After the mill, turn right and follow the road-work signs that say "detour", untill you turn left onto the Devon Valley road.
- Follow the road for a couple of kilometres and turn left at the Clos Malverne sign.
- The wine farm is straight ahead, on your right, just before the top of the hill.



Programme for SANUM 2011

Time	Wednesday 23 March	Thursday 24 March	Friday 25 March
08:15—09:00	**Registration** (Van der Sterr building)		
09:00—10:00	*Chair: Weideman* Plenary I (Room 1052) ***Nick Trefethen*** *Six myths of polynomial interpolation and quadrature*	*Chair: Herbst* Plenary I (Room 1052) ***Desmond Higham*** *Models and Algorithms for Evolving Networks*	*Chair: Laurie* Plenary I (Room 1052) ***Nick Trefethen*** *Introduction to Chebfun Computing*
10:00—10:30	Tea		
10:30—11:30	*Chair: Weideman* Plenary II ***Mike Powell*** *An inverse matrix for optimization without derivatives*	*Chair: Herbst* Plenary II ***Jared Tanner*** *Compressed Sensing: Theory and Software*	*Chair: Mason* Plenary II ***Douw Steyn*** *Modelling approaches to understanding the dynamics and kinematics of sea breezes*
11:30—12:00	Room 1052 (*Chair: Weideman*) **Dragomir** *Quadrature Rules for the Riemann-Stieltjes Integral and Applications* Room 1053 (*Chair: Herbst*) **Barashenkov** *Rocking modes of the sine-Gordon and* ϕ^4 *kinks*	Room 1052 (*Chair: Herbst*) **De Pierro** *Optimization, Compressed Sensing and Computed Tomography* Room 1053 (*Chair: Mahomed*) **Banda** *Relaxation Schemes for Nonlinear Partial Differential Equations*	Room 1052 (*Chair: Moitsheki*) **Bah** *RIC bounds and aysmptotics for Gaussian random matrices* Room 1053 (*Chair: Kara*) **Obaid** *Analysis of an HIV model with a distributed delay and behavioral change*
12:00—12:30	Room 1052 **De la Hoz** *Two-Dimensional Advection-Diffusion, Differentiation Matrices and Sylvester Systems* Room 1053 **Alexeeva** *Anisotropic solitons in the "subdiffractive" NLS on the plane*	Room 1052 **Fabris-Rotelli** *LULU Theory, the DPT and Scale-Space Theory* Room 1053 **Uoane** *A stability notion for Shallow Water Lattice Boltzmann Equation*	Room 1052 **Eneyew** *Methods for Solving Shifted Linear Systems with Application to Linear Parabolic PDEs* Room 1053 **Sidahmed** *Computational methods for option pricing problems on non-dividend paying assets*
12:30—14:00	Lunch		

14:00—14:30	*Chair: Makinde*	**Mason** *Thin slender rivulet on a porous substrate*	*Chair: Patidar*	**Molchan** *Stability of cnoidal waves in the parametrically driven nonlinear Schroedinger equation*	SANUM General Meeting			
14:30—15:00		**Abelman** *Stokes's first problem for a rotating Sisko fluid with porous space*		**Weideman** *A Numerical Methodology for the Painlevé Equations*	*Abelman*	**Elsheikh** *The effect of a distributed delay on the transmission dynamics of malaria*	*V. Rensburg*	**Ngnotchouye** *Particle Methods for the Solution of Nonclassical Systems of Conservation Laws*
15:00—15:30	Tea							
15:30—16:00	*Chair: Banda*	**Moitsheki** *Transient heat transfer in longitudinal fin of various profiles with temperature-dependent thermal conductivity*	*Chair: Laurie*	**Van Rensburg** *Solvability of a model for the vibration of a beam with a damping tip body*	*Chair: Abelman*	**Khabir** *Solving option pricing problems using spline techniques*	*Chair: V. Rensburg*	**Kara** *Conservation laws and conserved quantities of systems of PDEs*
16:00—16:30		**Harley** *Numerical investigation of a steady heat transfer in a longitudinal fin of various profiles*		**Basson** *Convergence of the finite element approximation for the vibration of a Timoshenko beam*		**Akanbi** *Application of a geometric explicit Runge-Kutta method to Pharmacokinetic models*		**Mahomed** *Laplace-Type Semi-Invariants for a System of Two Linear Parabolic Equations*
16:30—17:00		**Makinde** *Numerical investigation of unsteady MHD thermal boundary layer over a stretching sheet with a convective surface boundary condition*		**Layeni** *An atypical re-presentation of Goodman's profile and a Stefan problem*		**Mtemeri** *Numerical methods for singularly perturbed problems having discontinuous source terms*		**Pototsky** *Enhanced rectification of attracting particles in a single-file*
17:00—17:30		**Olayiwola** *Numerical Solutions of Generalized Burger's-Huxley Equation by Modified Variational Iteration Method*		**Bakheet** *Dynamics of the Non-autonomous Owen-Smith Model*		**Munyakazi** *Application of numerical singular perturbation methods to solve some cross-diffusion models in biology*		**Dutta** *Numerical Algorithm to Solve Nonlinear Hyperbolic Equations to Simulate Parallel Channel Instability in Boiling Water Nuclear Reactors*
19:00—	Welcoming Reception				Conference Dinner			

See http://dip.sun.ac.za/sanum for more information.

Wednesday 23 March

SIX MYTHS OF POLYNOMIAL INTERPOLATION AND QUADRATURE

Prof. Nick Trefethen (Oxford University)

Computation with polynomials is a powerful tool for all kinds of numerical problems, but the subject has been held back by longstanding confusion on a number of key points. In this talk I'll attempt to sort things out as systematically as possible by focusing on six widespread misconceptions. In each case I will explain how the myth took hold – for all of them contain some truth – and then I'll give theorems and numerical demonstrations to show why it is mostly false.

AN INVERSE MATRIX FOR OPTIMIZATION WITHOUT DERIVATIVES

Prof. Michael Powell (University of Cambridge)

A simple way of estimating the gradient of a function $F(y)$ of n variables is to calculate F at $n+1$ nondegenerate points y_i, $i=0,1,\ldots,n$, say, and to pick the gradient of the linear function that interpolates the values $F(y_i)$, $i=0,1,\ldots,n$. The nondegeneracy condition is that the volume of the convex hull of the points in n dimensions is nonzero. In other words, the $n\times n$ matrix Y that has the columns (y_i-y_0), $i=1,2,\ldots,n$, is required to be nonsingular, where, for convenience, the ordering of the points makes $F(y_0)$ the greatest of the values $F(y_i)$, $i=0,1,\ldots,n$. We consider the inverse of Y.
This setting occurs in some iterative algorithms for the unconstrained maximization of F, the estimated gradient being used as a search direction from y_0, which leads to a new interpolation point that replaces one of the old ones. Then Y and its inverse are updated for the next iteration. Similar replacements and updates are made on other iterations, where the new interpolation point is chosen to maintain an adequate volume of the convex hull, or to remove a point that is far from y_0. It is shown that the presence of the inverse matrix allows all the routine operations of each iteration to take only of magnitude n squared operations, which is important when n is large.
The $n+2$ values of F that are available when a replacement is made provide one piece of second derivative information. Thus, without calculating any more values of F, the data $F(y_i)$, $i=0,1,\ldots,n$, of the next iteration are interpolated by a very crude quadratic polynomial instead of by a linear one, the quadratic being produced by the "symmetric Broyden formula". We find that our inverse matrix allows this task also to be completed in only of order n^2 operations. Some numerical results demonstrate that the use of these quadratic polynomials instead of linear ones can increase greatly the efficiency of optimization algorithms.

QUADRATURE RULES FOR THE RIEMANN-STIELTJES INTEGRAL AND APPLICATIONS

Prof. Sever Silvestru Dragomir (University of the Witwatersrand)

Some quadrature rules for the Riemann-Stieltjes integral via the Ostrowski, Trapezoidal and Gruss' type inequalities are presented. Sharp a priory error bounds and applications in approximating continuous functions of selfadjoint operators in Hilbert spaces are given as well.

TWO-DIMENSIONAL ADVECTION-DIFFUSION, DIFFERENTIATION MATRICES AND SYLVESTER SYSTEMS

Dr Francisco De la Hoz (University of the Basque Country)

In this talk we describe a spectrally accurate, unconditionally stable, efficient method using operational matrices to solve numerically two-dimensional advection-diffusion equations on a rectangular domain at any arbitrarily large time, relating PDE's and Sylvester-type equations.

ROCKING MODES OF THE SINE-GORDON AND ϕ^4 KINKS

Prof. Igor Barashenkov (University of Cape Town)

The present study has been motivated by an ongoing debate on the existence of the internal mode of the sine-Gordon kink, the so-called Rice mode. The spectrum of linear excitations of the sine-Gordon kink does not include localised modes other than translations; however, a rocking motion of the kink is observed numerically and is reasonably accurately reproduced in collective-coordinate approximations.
Here, the rocking kinks are studied using a singular perturbation expansion combining collective coordinates of the excited kink with a hierarchy of space and time scales. We show that despite not having any discrete internal modes, the sine-Gordon kink may perform an osciilatory motion very similar to the one occurring when a discrete mode is excited. This localised rocking motion involves continuous spectrum of the kink. The amplitude of the rocking mode is shown to satisfy the (self-focusing)

nonlinear Schrödinger equation with a nonhomogeneous boundary condition at the origin.
The ϕ^4 kink is also shown to perform a rocking motion — in addition to the well familiar wobbling mode.

ANISOTROPIC SOLITONS IN THE "SUBDIFFRACTIVE" NLS ON THE PLANE

Dr Nora Alexeeva (University of Cape Town)

The periodic microscopic modulation of the external potential in optical and atomic systems results in a macroscopic modification of the net diffraction of wave packets. In particular, the envelopes of the Bloch modes satisfy the "subdiffractive" nonlinear Schroedinger equation on the plane: the cubic NLS combining second- and forth-order derivatives. We construct anisotropic soliton-like solutions of this equation and analyze their stability properties.

THIN SLENDER RIVULET ON A POROUS SUBSTRATE

Prof. David Paul Mason (University of the Witwatersrand)

A rivulet is a thin three-dimensional fluid film which flows down an inclined plane under gravity. The fluid is incompressible and Newtonian and the flow is unsteady with leak-off into the plane. Using the thin film approximation and assuming a slender rivulet a second order partial differential equation in one time and two spatial variables is derived. Using scaling transformations the partial differential equation is reduced in two steps to an ordinary differential equation.Numerical solutions are derived. It is found that the width of the rivulet decreases as time increases. The effect of fluid leak-off on the rivulet is investigated.

STOKES' FIRST PROBLEM FOR A ROTATING SISKO FLUID WITH POROUS SPACE

Prof. Shirley Abelman (University of the Witwatersrand)

Unsteady flow of a Sisko fluid induced by a suddenly moved infinite plate is investigated in a rotating frame. The fluid occupying the porous half space is electrically conducting in the presence of a variable magnetic field. Conservation laws of mass and momentum are utilised in the derivation of the differential equation. The modified Darcy's law is employed in the problem development. The governing non- linear problem is solved numerically. The effects of various parameters of interest on the velocity profile are shown explicitly.

STABILITY OF CNOIDAL WAVES IN THE PARAMETRICALLY DRIVEN NONLINEAR SCHROEDINGER EQUATION

Dr Max Molchan (University of Cape Town)

We study the linear stability of cnoidal wave-solutions of the parametrically driven, damped nonlinear Schroedinger equation. Out of two cn- and two dn-waves, two waves are shown to be unstable for all values of the driver's strength, dissipation and spatial period. We analytically and numerically establish that in the long wavelength limit the remaining cn type wave is stable if the driver's strength and the dissipation are small enough, while the dn-wave is unstable with respect to arbitrary quasi-periodic perturbations for all values of the governing parameters. We numerically investigate stability properties of cnoidal waves for different values of the spatial period for all values of the driver's strength and dissipation and discuss their temporal evolution dynamics.

A NUMERICAL METHODOLOGY FOR THE PAINLEVÉ EQUATIONS

Prof. André Weideman (Stellenbosch University)

We present a numerical methodology for the Painlevé equation, and demonstrate its performance on the PI equation. The key ingredient is that, in order to preserve numerical stability, different numerical methods are used in different regions of the complex plane. In the regions containing poles, the algorithm uses local Padé approximations combined with an initial-value stepping strategy that goes around the poles. In the smooth regions, a Chebyshev collocation method is used as a boundary-value solver. In the talk we report on the performance of the algorithm, and present solutions with fascinating pole field patterns that we believe have not been observed before. (Joint work with Bengt Fornberg.)

TRANSIENT HEAT TRANSFER IN LONGITUDINAL FIN OF VARIOUS PROFILES WITH TEMPERATURE-DEPENDENT THERMAL CONDUCTIVITY

Dr Raseelo Joel Moitsheki (University of the Witwatersrand)

Unsteady heat transfer through a longitudinal fin of various profiles is studied. Thermal conductivity and heat transfer coefficient are assumed to be temperature dependent. The resulting partial differential equation (PDE) is highly nonlinear. Classical Lie point symmetry methods are employed and some reductions are performed. In the case of the concave parabolic fin, the boundary conditions are invariant under the obtained symmetry at initial state. The governing boundary value problems (BVP) are solved numerically. The effects of the realistic fin parameter such as the thermo-geometric fin parameter and the exponent of the heat transfer coefficient on temperature distribution are studied.

NUMERICAL INVESTIGATION OF A STEADY HEAT TRANSFER IN A LONGITUDINAL FIN OF VARIOUS PROFILES

Dr Charis Harley (University of the Witwatersrand)

In this paper we consider a longitudinal fin with rectangular, triangular, concave and convex parabolic profiles attached to a stationary base surface. The heat transfer coefficient is given as a power law and the thermal conductivity as a linear function, allowing both to be temperature-dependent. Numerical solutions for the relevant energy balance equation for a longitudinal fin in dimensionless variables are obtained through the implementation of an in-built function, bvp4c, in MATLAB. Solutions are considered and compared for the mentioned profiles and various values of M and n which provides some useful insight into the problem at hand. The phase diagrams for each case are also considered as a means of investigating properties of the solutions obtained. This is a significant improvement to the study and construction of solutions for longitudinal fins of various profiles since, as far as the authors are aware, exact solutions in particular for the concave and convex parabolic cases are extremely difficult to obtain. Another novelty of the work undertaken in this paper is the choice of the forms for the heat transfer and thermal conductivity coefficients. Solutions in known literature have predominantly been considered when the heat transfer and thermal conductivity coefficient are both constants.

NUMERICAL INVESTIGATION OF UNSTEADY MHD THERMAL BOUNDARY LAYER OVER A STRETCHING SHEET WITH A CONVECTIVE SURFACE BOUNDARY CONDITION

Prof. Oluwole Daniel Makinde (Cape Peninsula University of Technology)

Hydromagnetic thermal boundary layer over a moving surface has an important bearing on several technical applications in engineering and industrial processes.In this talk, the combined effect of magnetic field and flow unsteadiness on thermal boundary layer over a stretching porous sheet with a convective surface heat exchange is investigated. By taking suitable similarity variables, the governing boundary layer equations are transformed into a set of coupled nonlinear ordinary differential equations and then tackled numerically using shooting quadrature. The effects of key parameters on the fluid velocity, temperature, skin friction and Nusselt number in the flow regime are depicted graphically and analyzed in detail. Comparison of numerical results is made with previously published results under the special cases, and found to be in good agreement.

References

[1] O. D. Makinde: MHD mixed-convection interaction with thermal radiation and nth order chemical reaction past a vertical porous plate embedded in a porous medium. Chemical Engineering Communications, Vol. 198 (4), 590-608, 2011.
[2] O. D. Makinde: On MHD heat and mass transfer over a moving vertical plate with a convective surface boundary condition. Canadian Journal of Chemical Engineering, Vol. 88, pages 983-990, 2010
[3] O. D. Makinde, A. Aziz: MHD mixed convection from a vertical plate embedded in a porous medium with a convective boundary condition, International Journal of Thermal Sciences, Vol. 49, 1813-1820, 2010.
[4] O. D. Makinde: Similarity solution of hydromagnetic heat and mass transfer over a vertical plate with a convective surface boundary condition. International Journal of Physical Sciences Vol. 5(6), 700-710, 2010.
[5] O. D. Makinde, P. O. Olanrewaju: Buoyancy effects on thermal boundary layer over a vertical plate with a convective surface boundary condition. Transaction of ASME –Journal of Fluid Engineering, Vol. 132, 044502(1-4), 2010.

NUMERICAL SOLUTIONS OF GENERALIZED BURGER'S-HUXLEY EQUATION BY MODIFIED VARIATIONAL ITERATION METHOD

Morufu Oyedunsi Olayiwola (Dept. of Mathematical & Physical Sciences, Osun State University Osogbo)

Numerical solutions of the generalized Burger's-Huxley are obtained using a Modified Variational Iteration Method (MVIM) with minimal computational efforts. The computed results with this technique have been compared with other results. The present method is seen to be a very reliable alternative method to some existing techniques for such nonlinear problems.

SOLVABILITY OF A MODEL FOR THE VIBRATION OF A BEAM WITH A DAMPING TIP BODY

Prof. Nic Janse van Rensburg (University of Pretoria)

We consider a model for the vibration of a beam with a damping tip body that appeared in a recent article. In this talk we derive a variational form for the motion of the beam and use it to prove that the model problem has a unique solution. Different cases are considered and the proofs are based on existence results for a general linear vibration model problem (in variational form).

CONVERGENCE OF THE FINITE ELEMENT APPROXIMATION FOR THE VIBRATION OF A TIMOSHENKO BEAM

Madelein Basson (University of Pretoria)

We consider a model problem for the vibration of a Timoshenko beam with boundary damping. Using a so called standard energy method, we prove that the Galerkin approximation converges to the solution and derive error estimates.

AN ATYPICAL RE-PRESENTATION OF GOODMAN'S PROFILE AND A STEFAN PROBLEM

Dr Olawanle Layeni (University of Cape Town)

Due to its extreme simplicity the heat balance integral method (HBIM), introduced by Goodman for addressing transport problems, has attracted lots of attention in recent times. In particular, the subtle objective of most of these have been that of significant improvement of its accuracy while retaining simplicity. A crucial factor in achieving this is the choice of test functions/profiles, of which holds little structure in current literature. It is shown, by elementary methods, how seemingly disjoint sets of earlier proffered profiles relate. Further, selected pertinent generators, leading to novel test profiles, are introduced and observed to yield remarkably accurate approximate solutions to a benchmark Stefan (melting) problem.

DYNAMICS OF THE NON-AUTONOMOUS OWEN-SMITH MODEL

Mohamed Bakheet (University of Cape Town)

We study the dynamics of the general non-autonomous case of Owen-Smith metaphysiological model, to explore the effects of seasonality on population fluctuations. The study will include the permanence, herbivore extinction, global asymptotic stability and existence of positive periodic solutions. Under certain assumptions, we obtained sufficient and necessary conditions for the permanency of the system. And also we obtained a sufficient condition for existence of periodic solutions.

Thursday 24 March

MODELS AND ALGORITHMS FOR EVOLVING NETWORKS

Prof. Desmond Higham (University of Strathclyde)

The digital revolution is generating novel large scale examples of connectivity patterns that change over time; this scenario may be formalized as a graph with a fixed set of nodes whose edges switch on and off. For example, we may have networks of interacting mobile phone users, emailers, Facebookers or Tweeters. To understand and quantify the key properties of such evolving networks, we can extend classical graph theoretical notions like degree and pathlength, and more general network science concepts such as centrality, to the dynamic setting.
In this talk I will focus on linear algebra-based ideas and show that computations based on matrix products can capture various aspects of information flow around an evolving network. Illustrative examples will be given for both synthetic and real-world data sets. I will also look at the issue of modeling this type of network evolution.

COMPRESSED SENSING: THEORY AND SOFTWARE

Prof. Jared Tanner (University of Edinburgh)

Compressed Sensing is a new data acquisition technique by which data can be sampled at the rate of its information content rather than the ambient dimension of the data. In special cases, precise sampling theorems have been derived, explaining the exact behavior of compressed sensing algorithms. However, for many algorithms, the sampling theorems are woefully pessimistic. We review the precise sampling theorems and show how a GPU based software package allows us to accurately calculate sampling theorems for other algorithms. This work is joint with David L. Donoho and Jeffrey D. Blanchard.

OPTIMIZATION, COMPRESSED SENSING AND COMPUTED TOMOGRAPHY

Prof. Alvaro De Pierro (University of Campinas)

Compressed Sensing (CS) is a new area of intense research in applied mathematics. For many important applications it allows to find the unique sparse solution of a very large underdetermined system of linear equations through l_1 minimization. In the case of imaging, l_1 is replaced by Total Variation (TV). If applicable in Computed Tomography, it would mean faster acquisition protocols and/or less radiation exposure for the patient. In this work we describe how old methods in Tomography could be adapted and generalized [1] for their application in the new CS setting. We also describe how this approach could be useful for estimating the associated regularization parameters [2] and we apply it to Single Photon Emission Computed Tomography (SPECT) data.

References

[1] E.S. Helou and A.R. De Pierro, Incremental subgradients for constrained convex optimization: a unified framework and new methods *SIAM J. Optimization,* 20, 3, 1547-1572, 2010.
[2] E.S. Helou and A.R. De Pierro, On Perturbed Steepest Descent Methods with Inexact Line Search for Bilevel Convex Optimization *Optimization* 60, 8, 2011.

LULU THEORY, THE DPT AND SCALE-SPACE THEORY

Inger Fabris-Rotelli (University of Pretoria)

The DPT is the repeated application of the LULU operators L_n and U_n. The resulting decomposition of an image provides a nonlinear scale-space, which we call the LULU scale-space. A formal setting and theory will now be provided for this new scale-space. Possible applications in image analysis will also be discussed.

RELAXATION SCHEMES FOR NONLINEAR PARTIAL DIFFERENTIAL EQUATIONS

Prof. Mapundi Banda (Wits)

A family of relaxation schemes for nonlinear partial differential equations will be presented. The schemes can achieve high-order of accuracy and give non-oscillatory solutions even in the presence of singularities. Test results for One- and two-dimensional results will be discussed.

A STABILITY NOTION FOR SHALLOW WATER LATTICE BOLTZMANN EQUATION

Tumelo Uoane (Wits)

Lattice Boltzmann (LB) equations are used as an alternative numerical formulation to simulate shallow water equations (SWEs). Hence, numerical stability of the method was investigated. The stability structure will be used as a guideline to determine the stability of LB equations applied to SWEs. For instant some of the parameters in the LB equations are adjusted based on the stability structure. With this method, stable LB models are prescribed.

THE EFFECT OF A DISTRIBUTED DELAY ON THE TRANSMISSION DYNAMICS OF MALARIA

Sara Elsheikh (University of the Western Cape)

We consider a vector-host model for the transmission dynamics of malaria with a gamma distributed delay. We analyze the impact of the delay on the steady states and their stability and determine a threshold value for the mean delay at which the system undergoes either a transcritical or a backward bifurcation. A sensitivity analysis is performed to compare the effect of the mean delay and shape parameter on the initial disease transmission and the disease prevalence at the equilibrium. Numerical simulations are carried out to confirm the theoretical findings to investigate the impact of the delay on the prevalence of the disease.
This is joint work with R. Ouifiki and K.C. Patidar.

SOLVING OPTION PRICING PROBLEMS USING SPLINE TECHNIQUES

Mohmed Khabir (University of the Western Cape)

In this talk we discuss construction and analysis of a numerical method for solving nonlinear Black-Scholes partial differential equation modelling European options. The governing equation is a diffusion problem. We use implicit time-stepping method together with the B-spline collocation method. The proposed method is unconditionally stable and has good convergence properties. The computational performance of the proposed method is compared with those obtained by using other methods.
This is joint work with K.C. Patidar.

APPLICATION OF A GEOMETRIC EXPLICIT RUNGE-KUTTA METHOD TO PHARMACOKINETIC MODELS

Dr Moses Adebowale Akanbi (University of the Western Cape)

Many physical phenomena are modeled by means of differential equations. In most cases, these equations are too complex to be solved exactly. In this talk we will briefly discuss the underlying theory of geometric explicit Runge-Kutta method. We then apply this approach to solve some mathematical models arising in Pharmacokinetics.
This is joint work with K.C. Patidar.

NUMERICAL METHODS FOR SINGULARLY PERTURBED PROBLEMS HAVING DISCONTINUOUS SOURCE TERMS

Nyika Mtemeri (University of the Western Cape)

In this talk, we consider a class of singularly perturbed problems with discontinuous source term. We provide some qualitative results on the solution of these problems. We then present a robust numerical method mimicking some of these qualitative properties along with some comparative numerical results.
This is joint work with J.B. Munyakazi and K.C. Patidar.

APPLICATION OF NUMERICAL SINGULAR PERTURBATION METHODS TO SOLVE SOME CROSS-DIFFUSION MODELS IN BIOLOGY

Dr Justin B. Munyakazi (University of the Western Cape)

Cross-diffusion models are being used to study various phenomena including in biology, epidemiology and medicine. Numerous nonlinear and complex dynamics have been observed in these models which can help to better understand the more challenging environmental and health problems such as pollution, invasion of species, emerging of new diseases and surging of the existing ones. While a vast literature presents qualitative investigations of such models, very little quantitative work has been done to date. Usually these models are highly nonlinear and involve large systems of differential equations, thus putting a real challenge to solve them analytically. It is therefore imperative to seek robust numerical methods for their solutions. In this talk we review some of these models that arise in biology. We then show how the methods developed for singularly perturbed reaction-diffusion problems can be used to solve these cross-diffusion models.
This is joint work with K.C. Patidar.

PARTICLE METHODS AND NON DISSIPATIVE CENTRAL UPWIND SCHEMES FOR THE SOLUTION OF NONCLASSICAL SYSTEMS OF CONSERVATION LAWS

Dr Jean Medard T. Ngnotchouye (University of kwaZulu-Natal)

In this talk, we review and compare two different numerical schemes for the solution of nonclassical system of conservation laws. Our interest is in the particle method of Chertock et Kurganov and the non dissipative Central Upwind scheme of Kurganov and Lin. Our investigations show that the particle method depends heavily on the recovery procedure while the Central-Upwind scheme give poor resolution of the delta-shocks. An hybridization of these methods is considered. We present numerical results related to applications in pressureless gas dynamics.

CONSERVATION LAWS AND CONSERVED QUANTITIES OF SYSTEMS OF PDES

Prof. Abdul Kara (University of the Witwatersrand)

The conserved quantities of systems of PDEs are significant in the study of the systems as they indicate the validity of solutions that are obtained by some approach. This is particularly useful in the case of numerical approaches. We develop a procedure to determine the conserved densities for a number of well known scalar PDEs and systems of PDEs and determine conserved quantities for soliton like solutions.

LAPLACE-TYPE SEMI-INVARIANTS FOR A SYSTEM OF TWO LINEAR PARABOLIC EQUATIONS

Prof. Fazal Mahomed (Wits)

We obtain new semi-invariants for a system of two linear parabolic partial differential equations (PDEs) in two independent variables under equivalence transformations of the dependent variables only. This is achieved for a class of systems of two linear parabolic PDEs that correspond to a scalar complex linear (1+1) parabolic equation. The complex transformations of the dependent variables which map the complex scalar linear parabolic PDE to itself provide us with real transformations that map the corresponding system of linear parabolic PDEs to itself with different coefficients in general. The semi-invariants deduced for this class of systems of two linear parabolic equations correspond to the complex semi-invariants of the complex scalar linear parabolic equation. We also look at particular cases of the system of parabolic equations when they are uncoupled or coupled in a special manner. Moreover, we address the inverse problem of when systems of linear parabolic equations arise from analytic continuation of a scalar linear parabolic PDE. Examples are given to illustrate the method implemented.

ENHANCED RECTIFICATION OF ATTRACTING PARTICLES IN A SINGLE-FILE

Dr Andrey Pototsky (University of Cape Town)

We study the rectification current of a single-file of attracting particles subjected to a low frequency ac drive and a static ratchet-like potential. Dilute or weakly attracting particles are evenly spread among the local minima of the ratchet potential, their jumps into the neighboring wells being randomly activated by noise and drive, with a bias in a preferred direction (ratchet mechanism). We show that increasing the particle attraction leads to the formation of a condensed mode, where the particles move as a whole following the ac drive. As a result, the ensuing net particle current may be one order of magnitude larger than for dilute or weakly attracting particles.

NUMERICAL ALGORITHM TO SOLVE NONLINEAR HYPERBOLIC EQUATIONS TO SIMULATE PARALLEL CHANNEL INSTABILITY IN BOILING WATER NUCLEAR REACTORS

Dr Goutam Dutta (IIITDM Jabalpur)

A numerical model is developed to solve nonlinear simultaneous equations to analyze two-phase flow boiling in vertical channels of the Boiling Water Nuclear Reactor core. The numerical model takes into account mass, momentum and energy conservation equations to simulate flow dynamics phenomena and classifies the set of equations as hyperbolic in nature. The model first transforms conservative form of the partial differential equations into primitive form and then into characteristic form and then finally solves them in time domain in Eulerian frame of reference with a characteristic based approach. The numerical algorithm is an efficient method because it takes into consideration of the compressibility effect of two-phase flow dynamics, it treats the boundary conditions naturally and it provides adequate accuracy with reasonable time in comparison to the method of characteristics technique which is considered to be benchmark solution while solving similar problems. The numerical model is next extended to analyze density wave oscillations in boiling reactor core and it simulates parallel channel instability of the reactor core undergoing both in-phase and out-of- phase modes of oscillations. The present paper provides the mathematical support to determine the boundary conditions to be imposed while simulating both in-phase and out-of-phase modes of instabilities and defines them explicitly so that one can simulate the parallel channel instability with such numerical algorithms. The model is then extended to investigate the effect of asymmetric power distribution in two halves of the reactor core in the context of reactor stability. Extensive numerical investigations are being carried out to determine whether the reactor instability when undergoing out-of-phase mode of oscillations is going to be enhanced or suppressed when subjected to asymmetric power distribution in comparison to the symmetric power distribution keeping the total power and mass flow rate same for both the cases. Analysis of asymmetric power distribution on the reactor instability will help in simulating the reactor with the present numerical model for more realistic operating conditions.

Friday 25 March

INTRODUCTION TO CHEBFUN COMPUTING

Prof. Nick Trefethen (Oxford University)

Anyone who uses Matlab (or Octave or Scilab) will enjoy Chebfun, which overloads Matlab commands for vectors and matrices to analogous commands for functions and operators. In Chebfun, all it takes to solve a differential equation is "backslash". In this online talk I'll briefly describe how Chebfun works and the growth of the Chebfun project, and then spend most of the time showing off the software. If you have a laptop with Matlab, feel free to bring it with you and play along. Chebfun can be downloaded from www.maths.ox.ac.uk/chebfun/, and copies will also be available on a memory stick. This is joint work with Toby Driscoll, Nick Hale, and about a dozen other members of the Chebfun team.

SEA BREEZES: THE PHENOMENON, AND SOME APPROACHES TO UNDERSTANDING THEIR DYNAMICS AND KINEMATICS

Prof. Douw Steyn (The University of British Columbia)

I will present the phenomena of sea breezes as an ideal geophysical fluid dynamical object of study. I will describe the phenomenon, explain some of its more interesting features and make an assertion that a particular sea breeze made western civilization a possibility! I will then present a simple, linear analytical model of sea breezes due to Bernard Haurwitz and will show how that work led to a wide range of analytical modelling studies. I will introduce the use of atmospheric numerical models as research tools, and will summarize some of my work designed to understand the interplay of forces driving sea breeze dynamics, using a fully nonlinear numerical model. I will present empirical scaling laws for sea breeze strength and depth, and will showin how the output of a numerical model of sea breezes can be used in further developing sea breeze scaling.

RIC BOUNDS AND AYSMPTOTICS FOR GAUSSIAN RANDOM MATRICES

Bubacarr Bah (University of Edinburgh)

The Restricted Isometry Constants (RIC) of a matrix A measures how close to an isometry is the action of A on vectors with few nonzero entries, measured in the Euclidean norm. Specifically, the upper and lower RIC of a matrix A of size n by N is the maximum and the minimum deviation from unity (one) of the largest and smallest, respectively, square of singular values of all submatrices formed by taking k columns from A. Calculation of the RIC is intractable for most matrices due to its combinatorial nature; however, many random matrices typically have bounded RIC in some range of problem sizes (k,n,N). We provide the best known bound on the RIC for Gaussian matrices, which is also the smallest known bound on the RIC for any large rectangular matrix. Our results are built on the prior bounds of Blanchard, Cartis, and Tanner in Compressed Sensing: How sharp is the Restricted Isometry Property?, with improvements achieved by grouping submatrices that share a substantial number of columns. Furthermore, using asymptotic approximations of RIC bounds we give further insight into the order of measurements necessary to guarantee exact recovery in Compressed Sensing by computing values of the constants in the order terms for some key recovery algorithms in Compressed Sensing.

METHODS FOR SOLVING SHIFTED LINEAR SYSTEMS WITH APPLICATION TO LINEAR PARABOLIC PDES

Eyaya Birara Eneyew (Stellenbosch University)

In several applications shifted linear systems of the form (A - aI)x = b needs to be solved for several values of the parameter a. Often, these linear systems are large and sparse. In this talk we present efficient solutions of these systems by the Krylov subspace methods. Because of its shift-invariance property, the Krylov subspace method allows one to obtain approximate solutions for all values of the parameter, by generating a single approximation space. Krylov subspace methods applied to the shifted systems are generally slowly convergent and hence preconditioning is necessary to improve the convergence. The use of shift-invert preconditioning is discussed and numerical comparison of the direct sparse solver with the Krylov subspace methods are presented. As application we solve a two-dimensional version of the heat equation.

ANALYSIS OF AN HIV MODEL WITH A DISTRIBUTED DELAY AND BEHAVIORAL CHANGE

Hasim Obaid (University of the Western Cape)

We consider a mathematical model for the transmission dynamics of HIV that accounts for behavioral change. The model also includes a distributed delay

representing the time needed for individuals to reduce their risky behavior. The impact of the delay on the stability of the steady states as well as on the bifurcation behavior of the system is studied. Numerical simulations supporting the theoretical findings will be presented at the conference.
This is joint work with R. Ouifki and K.C. Patidar.

COMPUTATIONAL METHODS FOR OPTION PRICING PROBLEMS ON NON-DIVIDEND PAYING ASSETS

Abdelmgid Sidahmed (University of the Western Cape)

In this talk we consider some differential equation models describing options on non-dividend paying assets. Our major focus will be on the plain vanilla options, e.g., European and American options. We will discuss some computational methods to solve them followed by comparative numerical results.
This is joint work with K.C. Patidar.

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