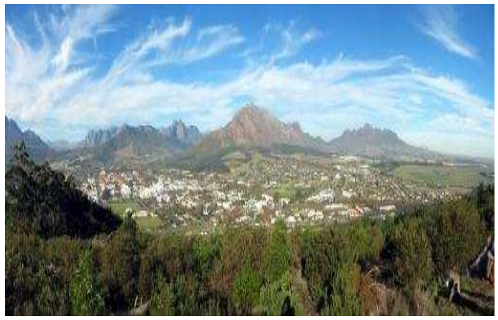




29th Annual Conference

of the

South African Society for Numerical and Applied Mathematics

hosted at the

University of Stellenbosch

30 March - 1 April, 2005

PROGRAM 2005

	Wednesday			Thursday		Friday	
08:00-08:50	REGISTRATION						
Chair:	Room 3021 (Herbst)			Room 3021 (Watson)		Room 3021 (Snyman)	
08:30–08:50	**08:50 Opening Remarks**			**Lyness**		**Tokieda**	
09:00–09:50	**Watson**			**Milovanovic**		**Mason**	
10:00–10:30	TEA			TEA		TEA	
Chair:	(Weideman)			(van Rensburg)		(Laurie)	
10:30–11:20	**Butcher**			**Stynes**		**Cuyt**	
Chair:	Room 3021 (Abelman)	Room 3018 (du Preez)		Room 3021 (Bishop)	Room 3018 (du Plessis)	Room 3021 (Cuyt)	Room 3018 (Witten)
11:30–11:50	**Shindin**	**Schwardt 1**		**Mala**	**Smit**	**Verdonk**	**Ouifki**
12:00–12:20	**Kulikov**	**Nel**		**Snyman**	**Halvorsen**	**Deschrijver**	**Malm**
12:30–14:00	LUNCH			LUNCH		LUNCH	
Chair:	Room 3021 (Mason)	Room 3018 (du Preez)	Room 2016 (Weideman)	Room 3021 (van der Merwe)	Room 3018 (Smit)	Room 3021 (Labuschagne)	Room 3018 (Witten)
14:00–14:20	**Bishop**	**Cilliers**	**Mare**	**de Villiers**	**de Beer**	**Yang**	**Mugwagwa**
14:30–14:50	**Abelman**	**Jacobs**	**Sherwell**	**Dongmo**	**Terblanche**	**Hendrickx**	**Nyandwi**
15:00–15:20	**Banasiak**	**Schwardt 2**	**Prodinger**	**Hunter**	**Woudberg**	**Kara**	**Altaj**
15:30-16:00	TEA			TEA		TEA	
Chair:	Room 3021 (Kara)	Room 3018 (du Preez)	Room 2016 (Banasiak)	Room 3021 (de Villiers)	Room 3018 (Smit)	Room 3021 (Rohwer)	Room 3018 (Witten)
16:00–16:20	**van Rensburg**	**Malan**	**Cloete**	**du Toit**	**Nguetchue**	**van Rooyen**	**de Beaudrap**
16:30–16:50	**Labuschagne**	**van der Walt**	**Patidar**	**Harper**	**Parumasur**	**Weideman**	**Amin**
17:00–17:20	**van der Merwe**	**Brink**	**Botha**	**Rohwer**	**Ravindran**	**Laurie**	**Banda**

Plenary talks: Each day 09:00–09:50 and 10:30–11:20, Room 3021
Special Session I: Image Processing and Pattern Recognition, Wednesday 11:30–17:30, Room 3018
Special Session II: Porous Media, Thursday 11:30–17:30, Room 3018
Special Session III: Biomathematics, Friday 11:30–17:00, Room 3018

Registration, tea breaks, lunches

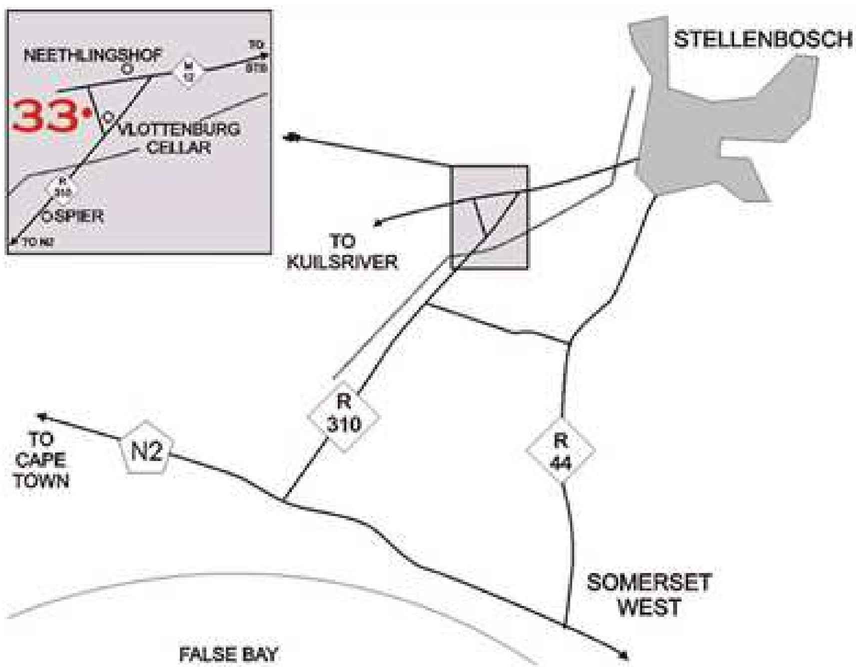
Registration is on Wednesday, 30 March, from 8:00 to 8:50 in the tea room of the Mathematics Department (on 3^{rd} floor). Then proceed to Room 3021 where all the plenary talks will be held. All tea breaks will also be held in the tea room of the Mathematics Department (on 3^{rd} floor). Lunch will be taken at The Naked Truth, on Andringa Street (see map on last page).

Lunches

Lunches, included for all regular and student conference participants, are at The Naked Truth, on Andringa street (see map on last page).

Conference Dinner

The conference dinner is on Thursday evening at 33 Stellenbosch Restaurant, just off Baden Powell drive. Transport will be arranged and will leave at 18:30 from the parking area in front of the Mathematics department, to arrive at the restaurant at 19:00.



Email

Email and internet access is available in room A218, Building 39 (see map). Login and passwords will be provided by the organisers.

List of Speakers

[Wed, 14:30, Room 3021]

Numerical Solution of Emden's Equation

Shirley Abelman

School of Computational and Applied Mathematics
University of the Witwatersrand
abelman@cam.wits.ac.za

Stiffness, a subtle, difficult and important concept in the numerical solution of ordinary differential equations, depends on the differential equation, the initial conditions, and the numerical method. Definitions of the word "stiff" involve terms like "not easily bent", "rigid", and "stubborn". This talk is concerned with a computational version of these properties.

[Fri, 15:00, Room 3018]

Spatial distribution and abundances of species in mathematical ecology: A percolation approach

Mohammed Altaj, Edith Perrier, Henri Laurie and Gareth Witten

Department of Mathematics and Applied Mathematics, University of Cape Town, South Africa

mohammed@aims.ac.za, perrier@bondy.ird.fr, henri@maths.uct.ac.za and gareth@maths.uct.ac.za

The relationships between distribution and abundance of species are important and numerous because it has links to other fields such as biodiversity. Macroecology can be described as the study of emergent patterns of assemblages of species distributed over geographical spatial scales. There are a number of mathematical models being developed to quantify this relationship in a number of contexts. He and Hubbell(2003) claimed that they have possibly unified several fundamental ecological parameters including abundance (N), distribution of pattern (k), scale (a), extent (A) and edge length (L) into a single mathematical framework for the spatial architecture of fragmented metapopulations. They establish a relationship between perimeter and abundance and between the number of patches and abundance.

We show that all relationship presented by He and Hubbell(2003) are holds in our case study by using random distribution of dots in the study area.

[Fri, 16:30, Room 3018]

Modelling the effect of a dendritic-cell vaccine for chronic HIV-1 infection

Bayan Amin, Tendai Mugwagwa and Gareth Witten

African Institute for Mathematical Sciences,Muizenberg, Cape Town,
and
Department of Mathematics and Applied Mathematics, University of Cape Town
bayan@aims.ac.za, tendai@aims.ac.za, gareth@maths.uct.ac.za

The continued spread of the HIV epidemic provides compelling evidence for the need for an AIDS vaccine. A wide variety of AIDS vaccines have been developed, but the most successful is the dendritic_cell based vaccine for HIV-1, which was developed by Lu et al, 2004. They showed in a clinical trial with 18 chronically HIV-1-infected individuals that the viral load decreased by up to 80% . The duration of this study was one year. We developed a model that describes the antigen presenting role of dendritic_cells, and how they contribute to the development of immunity against HIV. We extend the model to include the effect of dendritic_cell based vaccine. We use the model the infer the long term outcome of the vaccine.

[Wed, 15:00, Room 3021]

Interplay of different time scales in asymptotic analysis

Jacek Banasiak

University of KwaZulu-Natal
banasiak@ukzn.ac.za

In asymptotic analysis we investigate the behaviour of the system when one (or more) parameters of the system is very small or very large. Selection of these parameters is done usually by analysing the relative scale at which various part of the system operate. Examples of this type are rendered by coexistence of fast and slow mechanisms driving the evolution of a system. In this talk we shall describe a kinetic equation describing the evolution of particles undergoing elastic and inelastic collisions, e.g. electrons moving through a crystalline lattice or neutrons in ionised gases and we shall show that, depending on relative time scales of inelastic and elastic collisions, the limit equation can vary from a diffusion equation through diffusion-kinetic equation to isotropic kinetic equation.

[Fri, 17:00, Room 3018]

Relaxation schemes and their application to hyperbolic flow models

Mapundi K. Banda

School of Mathematical Sciences, University of KwaZulu-Natal
bandamk@ukzn.ac.za

In this paper we present numerical methods based on a relaxation approach for computing different flow models. The methods are based on the classical relaxation models combined with Runge-Kutta splitting schemes, where neither Riemann solvers nor characteristic decompositions are needed. In the relaxation approach a nonlinear conservation law is approximated by a relaxation system which is linear. The idea is to use a local linear approximation to construct linear hyperbolic systems with stiff lower order terms that approximate the original system with a small dissipative correction. A higher-order numerical scheme, for example, the MUSCL scheme or CWENO scheme, is applied to the linear relaxation system. The derived scheme enjoys the advantage of simplicity, accuracy as well as robustness and can be applied to problems of practical relevance. The only characteristic information needed in the construction is the local characteristic speed. Even when a local characteristic decomposition is hard to obtain, an accurate approximation of the local speeds is sufficient. This simplicity can be of great importance if one has to solve large-scale problems. Numerical results are presented for several test carefully selected problems.

Keywords: Relaxation Systems, Relaxation methods, Semi-discrete systems, hyperbolic systems, higher order upwind schemes, Runge-Kutta methods.

[Wed, 14:00, Room 3021]

Gravitational radiation: numerical code, and series solution by means of computer algebra

Nigel T. Bishop

University of South Africa
bishont@unisa.ac.za

We have written a code to compute the gravitational radiation emitted in certain astrophysical events. While the gravitational field obtained is convergent, the radiation is not. Isolating the problem is difficult because there are no exact solutions available that could be used to test the numerically generated values of the intemediate variables. This motivated the construction of analytic solutions as series, under particular circumstances, by means of computer algebra.

[Wed, 17:00, Room 3018]

Parameterization methods for closed 3D surfaces

Willie Brink

Department of Applied Mathematics, University of Stellenbosch
whbrink@dip.sun.ac.za

The surface parameterization of digital three-dimensional models is a fundamental problem in computer graphics. Parameterization is the first step in applications such as sampling, multiresolutional analysis, filtering, morphing and texture mapping.

In this talk, we consider models homeomorphic to the unit sphere. An obvious choice for the parameter domain is therefore the surface of the sphere. When representing the surface of a 3D model by means of a polygonal mesh, the problem of parameterization can be solved by embedding the underlying graph (or 1-skeleton) of the mesh on the surface of the sphere. A valid spherical embedding means assigning coordinates to every vertex of the graph, such that when drawing this graph on the sphere, no edge-intersections occur.

Techniques to embed the graph of a mesh on the sphere include Laplacian relaxation (with and without boundary values), and the method of progressive meshes. We shall discuss a few of these, and illustrate it by means of some interesting examples.

[Wed, 10:30, Room 3021]

General linear methods

John Butcher

Department of Mathematics, The University of Auckland, New Zealand
butcher@math.auckland.ac.nz

General linear methods were originally introduced as a unifying framework to relate concepts such as consistency, stability and convergence. However, within this general class, practical methods exist which cannot be formulated as either Runge-Kutta methods or as linear multistep methods.

This talk will survey some of the theoretical ideas behind general linear methods with particular reference to the meaning and significance of order of accuracy. Some special methods and families of methods will be discussed and progress will be reported on recent attempts to construct, and to provide efficient implementations for, methods satisfying the so-called inherent RK stability property. Reference will also be made to the relationship between order and stability in the search for new and efficient methods to solve stiff problems.

[Wed, 16:00, Room 2016]

The Cordic algorithm (COordinate Rotation DIgital Computer)

M. Cloete, M.F. Maritz and J.A.C. Weideman

Department of Applied Mathematics, University of Stellenbosch,
mcloete@sun.ac.za

How can one calculate functions such as $\sin(x)$ and $\cos(x)$ with simple operations? This was the question Jack E. Volder was faced with in the 50s, when he had to design algorithms for $\sin(x)$ and $\cos(x)$ for the computer chips with limited memory then available. He succeeded in formulating the Cordic algorithm in 1959.

The functions are calculated by operations which can be implemented directly in machine code, using only:

- The recall of stored values
- Adding and subtracting
- Change of sign
- The shifting of a binary value relative to its binary point, in other words, multiplication and division by two.

Today, the Cordic algorithm is implemented in calculators where the memory is still limited.

This talk will explain the basic idea behind this algorithm.

[Fri, 10:30, Room 3021]

Rational approximation theory and scientific computing

Annie Cuyt

University of Antwerp, Belgium
Annie.Cuyt@ua.ac.be

In recent years several highly technological problems could profit from some classical results in rational approximation theory, as can be seen from the existing literature. We discuss following selected problems:

- The computation of the packet loss probability as a function of the buffer size in the context of multiplexing techniques, to support variable bit rate communication, can be realized in almost real-time making use of multipoint Pad-type approximants.
- The reconstruction of general two- and three-dimensional shapes from indirect measurements such as bi- and trivariate moment information, is possible because of the relationship between several integral transforms and homogeneous multivariate Pad approximants.
- Models describing complicated physical devices or extremely time-consuming simulations, can be highly simplified using adaptive scattered rational interpolation, while maintaining at the same time a required accuracy.
- A large collection of special functions from science and engineering, can be evaluated reliably and efficiently by means of modified continued fraction approximants, guaranteeing evaluations up to a user defined accuracy which can be chosen from a few digits to several hundreds or thousands, truncation and round-off error included.

[Wed, 14:00, Room 3018]

Tree-based Gaussian Mixture Models

Francois Cilliers

Department of Electronic and Electiric Engineering, University of Stellenbosch
fcilliers@ieee.org

The Gaussian mixture model (GMM) performs very effectively in many pattern recognition tasks, such as in speech and speaker recognition applications. However, the speed of evaluating a model is greatly reduced when the number of mixture components in each model becomes large. Many techniques have been developed to improve the evaluation speed. The main aim is to reduce the number of required Gaussian evaluations. This approach is based on the observation that only a few mixture components contribute significantly to the final model likelihood.

One technique that shows promise beyond the basic speed improvement, is a tree-based model structure. The nodes in each layer of the tree act as approximations to nodes further away from the root node. The mixture components of the GMM are represented by the leaf nodes in the tree structure. The group of mixture components that contribute the most to the model likelihood can then be found quickly by searching through the approximate nodes that also have the highest contributions. The speed improvement is tightly dependent on the structure of the model and the number of mixture components. The tree-based model can also improve the speed of model training.

We introduce a new version of the model, called a tree-based adaptive Gaussian mixture model (T-BAGMM). This model not only searches for the components with the highest likelihood contributions, but it also produces a virtual regular GMM using approximate nodes for the remaining mixture components in the model. The computation required is nearly the same as for other tree-based models, because those approximate nodes are already evaluated during the search procedure. We show that up to nearly a hundred-fold increase in evaluation speed is obtained for models with 2048 mixture components. We also show that the performance of the T-BAGMM at this speed is similar to that of the regular GMM.

[Fri, 16:00, Room 3018]

Switching between fat and glucose oxidation in lean and obese children: A Preliminary Model

Pierre De Beaudrap and Gareth Witten

Stellenbosch Institute for Advanced Study, 19 Jonkershoek Road, Mostertsdrift
and
Department of Mathematics and Applied Mathematics, University of Cape Town
pdebeaudrap@yahoo.fr, gareth@maths.uct.ac.za

In lean and healthy people, there is a switch between predominant fat oxidation rate under fasting conditions and a predominant glucose utilization in insulin-stimulated conditions. This adaptation of the fuel to environmental conditions is progressively lost in insulin-resistant states. Under basal conditions, fat oxidation is compensated by an increase in glucose oxidation that uses glycogen store. The switch after insulin-stimulation is also impaired because of the decrease in glucose uptake caused by an insulin signal. This signal is altered because of lipid accumulation in the cell.

We will present preliminary results based on a mathematical model that represents the aggregated metabolic pathways involved in the energy metabolism in skeletal muscle cells. Inputs to the model include lipid, glucose and amino acid level in the blood and outputs are the different type of energy expenditure (resting energy expenditure, food energy expenditure and exercise energy expenditure).

[Thur, 14:00, Room 3018]

Porous Media Imaged by Neutrons

FC de Beer, MF Middleton

Necsa: Building 1500, Necsa, POBox 582, Pretoria, 0001, South Africa
and
MURDOCH UNIVERSITY, Perth, Australia.
fdebeer@necsa.co.za

Simulations and theoretical modeling of fluid flow principles, with limited magnetic resonance (NMR) experimental backing, form the basis of scientific knowledge of fluid flow transport phenomena in porous media. The reality, however, is that neutron radiography (NRad) as analytical technique with its unique detection and discrimination capabilities of the elements, provides the necessary and long seeking information to streamline existing fluid flow models in porous media[1,2,3].

The distinct advantage of NRad is that quantitative distribution information of the characteristics of porous media can be obtained non-destructively and the use of CCD imaging enhances the ease to obtain quantitative information. Dynamic neutron radiography, however, provides the necessary information to streamline existing fluid flow models in oil filled sandstone reservoir rock [4]. Petrophysical imaging with neutron radiography is an advanced core analysis technique that is able to directly image one and two phase flow of fluids within porous media. [5] There is no other technique able to do this. The use of neutrons in an imaging environment presents a revolutionary new paradigm for scientist and engineers involved.

The South African Nuclear Energy Corporation (Necsa), recently equipped one its neutron beam lines at the SAFARI-1 nuclear materials research reactor, near Pretoria, [6] with the newest cooled CCD tomography imaging system for neutron radiography and -tomography R&D studies. The South African Neutron Radiography/tomography (SANRAD) facility is being utilized by industry for non-destructive purposes, but the facility tends to be used even more in the field of R&D and characterization of porous media, [7].

Recent feasibility studies conducted at the SANRAD facility indicated that NRad has the capability to provide quantified information of the following parameters of porous media (for example: % water distribution, % porosity distribution, permeability, % oil and -water in core after flooding, the imbibition of wetting liquids and the solution for the general two-phase fluid-flow diffusion equation.) The beam line facilities on the beam port floor of the SAFARI-1 reactor is made available (for free) by Necsa for post graduate studies from higher educational institutions to proceed with proper R&D into the properties of porous media.

References

1. Nemec, T., Rant, J. and Kaling, M., 1997, Detection of Moisture and Hydrogenous Liquids in Building materials by Direct Near-Real-Time Neutron Radiography techniques, IAEA Tech. Committee Meeting on Neutron Beam Research, Sept 1997, p119-125.

2. Pleinert, H., Lehmann, E., 1996, Quantitative neutron radiography measurement of hydrogenous distributions. Proceedings of the 5th World Conference on Neutron

Radiography, June, Berlin, Germany, p586-593.

3. Justnes, H., et.al., 1994, Neutron Radiography: An excellent method of measuring water penetration and moisture distribution in cementitious materials., Advances in Cement Research, 6, No 22, p67-72.

4. Middleton, M.F., De Beer, F.C., Hilson, J., 2001, Neutron Imaging of reservoir rocks and iron ore, Proceedings of the 5th SAGJ International Symposium – Imaging Technology, Society of Exploration Geophysics of Japan, ISBN# 4-938493-05-5, p263-268.

5. De Beer, F.C., Middleton M.F., 2004, Neutron Radiographic of porous rocks and iron ore, J. Appl. Rad and Isot. Vol61, p487-495.

6. De Beer, F.C., and Strydom, W.J., 2000, Neutron radiography at SAFARI-1 in South Africa, Non-destructive Testing and Evaluation, Vol.16, pp163-176.

7. De Beer, F.C., Griesel, B., et. al., 2004, The drying process of concrete: a Neutron Radiography study, J. Appl. Rad and Isot. Vol61, p617-623.

[Fri, 12:00, Room 3021]

On the use of rational approximation techniques in engineering

Dirk Deschrijver

University of Antwerp
dirk.deschrijver@pandora.be

Linear Time Invariant (LTI) systems can be characterized in the frequency domain by compact rational macromodels. Analytic rational models are very important for efficient time domain and frequency domain simulation of LTI systems, such as high-speed passive interconnection structures. Traditionally, a Vandermonde-like system of equations is solved to determine all model parameters. The main disadvantage of this approach is that the accuracy is limited for highly dynamic systems due to numerical issues.

In this talk, an overview is given of some recent developments that significantly can improve the stability of the system identification problem. The link with the Padé approximation will be shown.

[Thur, 14:00, Room 3021]

On refinable functions and subdivision with positive masks

Johan de Villiers

Department of Mathematics, University of Stellenbosch
jmdv@sun.ac.za

A fundamental issue in the mathematical analysis of both subdivision and wavelets is the study of finitely-supported continuous solutions ϕ of the refinement equation

$$\phi(x) = \sum_{j=0}^{n} a_j \phi(2x - j), \quad x \in \mathbb{R},$$

with $\{a_j : \ j = 0, 1, \ldots, n\}$ denoting a given real sequence, called the mask sequence. In this talk we consider specifically those cases for which $a_j > 0, \ j = 0, 1, \ldots, n$, and we establish a constructive existence theory for the refinable function ϕ by means of the cascade algorithm. In the process we derive explicit bounds in terms of the mask sequence for the geometric convergence rate of both the cascade algorithm and the resulting subdivision scheme. Also, we present a set of sufficient conditions on the mask sequence which guarantees a prescribed regularity (or smoothness) degree for the refinable function ϕ.

[Thur, 14:30, Room 3021]

On subdivision convergence and refinable function existence

G. Blaise Dongmo

Department of Mathematics, University of Stellenbosch
dongmo@sun.ac.za

According to a well-known result, the convergence of a subdivision scheme implies the existence of a solution of the corresponding refinement equation. The converse does not hold: there do indeed exist refinable functions for which the corresponding subdivision schemes diverge. We present here a characterisation due to M. Neamtu of those mask symbols for which we have both subdivision convergence and refinable function existence, and we illustrate the theory with examples.

[Thur, 16:00, Room 3021]

Median Transforms in Image Processing.

JP du Toit and CH Rohwer

Department of Mathematics, University of Stellenbosch
chr@sun.ac.za

Consensus is claimed to be that Median Transforms are better for decomposition and smoothing of two-dimensional images,particularly those like photos of the night sky, where dark rings around bricht point sources are typical artifacts resulting from linear smoothing. Some popular schemes are investigated to highlight and investigate.We compare with alternatives.

[Thur, 12:00, Room 3018]

Experimental and Computational study of a bubbling fluidised bed

Britt Halvorsen and Vidar Mathiesen

Telemark University College and Telemark Technological R&D Centre (Tel-Tek)
Britt.Halvorsen@hit.no

The flow behavior in a three-dimensional bubbling fluidized bed has been studied experimentally and computationally. The aim of the study is to increase the fundamental knowledge about how the particle size distribution influence the flow behavior and fluidisation in a fluidized bed. Simulations have been performed using a computational fluid dynamics (CFD) model named FLOTRACS-MP-3D, Mathiesen et al. (2000). The CFD model is based on an Eulerian description of the phases where the kinetic theory for granular flow forms the basis for the turbulence modeling of the solid phases. Simulations with both one and three solid phases are performed. A three-dimensional bubbling fluidized bed with a square cross-section is build. The dimension of the fluidized bed is 0.25x0.25x2.0 m. An experimental fluid dynamic (EFD) study with a fiber optical measurement system is performed. The flow behavior (i.e. bubble frequency, size and velocity) in the dense part of the bed is measured for different particle size distributions. Bubbles are also studied by using a video camera and a high speed camera. The pressure and pressure drop are measured at 10 different bed heights. The measurements show that the particle size and the particle size distribution influence the flow behavior significantly. The experimental and the computational results are compared and discussed.

References

Mathiesen, V., Solberg, T., Hjertager, B.H. (2000) An experimental and computational study of multiphase flow behavior in a CFB. *Int. J. Multiphase Flow*, Vol.26, pp.387-419

[Thur, 16:30, Room 3021]

Resolution Level Concensus in LULU-decomposition.

JP Harper and CH Rohwer

Electronic Developement House (EDH)
and
Department of Mathematics, University of Stellenbosch
chr@sun.ac.za

LULU-decompositions and their duals agree with their respective low- and high-pass components, but not with individual resolution components. Are there equivalent procedures that yield concensus on the resolution components, and what advantages may they have up their sleave?.

[Fri, 14:30, Room 3021]

Adaptive DACE Modeling.

Wouter Hendrickx

CoMS - Computer Modeling And Simulation of Complex Systems,
Department of Mathematics and Computer Science,
University of Antwerp, Belgium
wouter.hendrickx@ua.ac.be

Design and analysis of Computer Experiments, or DACE, is a deterministic version of the Kriging methodology. Given a set of (scattered) data points $x_i \in \mathbb{R}^d$ and corresponding function values $f_i \in \mathbb{R}$, it constructs a model $f : \mathbb{R}^d \to \mathbb{R}$ such that $f(x_i) = f_i$ for all i.

Using this methodology, we try to iteratively improve our model by adding samples (new x_i's with corresponding f_i's) where we expect our model to be inaccurate. By doing so, we arrive at a model with a guaranteed accuracy over the whole domain.

[Thu, 15:00, Room 3021]

A linear combination of two consecutive Dubuc–Deslauriers subdivision masks

Karin Hunter

Department of Applied Mathematics, University of Stellenbosch
karin@sun.ac.za

Convergent interpolatory subdivision schemes generate curves that interpolate a given set of data using a simple iterative procedure of combining a finite number of elements in given set of data to give a data point in a new data set. We define a class of interpolatory subdivision schemes, discuss the well-known Dubuc–Deslauriers subdivision scheme as an element of this class and show that any element in this scheme can be written in terms of the Dubuc–Deslauriers subdivision masks. We then focus on the specific case of a linear combination of two consecutive Dubuc–Deslauriers subdivision masks.

[Wed, 14:30, Room 3018]

Deterministic Tracking using Active Contours

Emmerentia Jacobs

Department of Electronic and Electrical Engineering,
University of Stellenbosch
ejacobs@dsp.sun.ac.za

Many industries today require the computerised tracking of objects that move in a video sequence. One example is teaching a computer to lipread by following the deformation of the speaker's lips.

The aim was to try and follow a moving object deterministically by repeatedly fitting contours to the moving object's outline. An important aspect of the algorithm was to allow certain deformations of the fitted curve to occur, whilst excessive deformations had to be prevented.

[Fri, 15:00, Room 3021]

Soliton and other exact solutions of the various KdV-type equations

AH Kara

School of Mathematics Wits University

kara@maths.wits.ac.za

In this talk, we show that the usual substitutions for stationary wave solutions can be explained by one-parameter Lie groups of transformations which allows one to adopt the methods to other similar evolution equations. In addition to this, we show that an exact solution for the combined KdV MKdV (modified KdV) can be obtained as a consequence of a nontrivial Lie point symmetry that the equation admits. These have all kinds of consequences when comparisons are made from numerical studies.

[Wed, 12:00, Room 3021]

Local and Global Errors Estimation in Nordsieck Methods

G. Yu. Kulikov and S.K. Shindin

University of the Witwatersrand, Johannesburg
gkulikov@cam.wits.ac.za

The paper deals with asymptotically correct methods to evaluate the local and global errors of Nordsieck methods applied to ordinary differential equations. It naturally extends the results developed by Kulikov and Shindin [Zh. Vychisl. Mat. Mat. Fiz., 44 (2004), pp.847–868] in local and global errors computation of multistep methods, but shows that their technique will become more complicated when implemented in numerical methods for which the concepts of consistency and quasi-consistency are not equivalent (see Skeel [SIAM J. Numer. Anal., 13 (1976), pp.664–685]). Special cases of Nordsieck methods with cheaper error estimation are also considered. Practical algorithms of the errors evaluation are obtained and verified on appropriate numerical examples clearly confirming the presented theory.

[Wed, 16:30, Room 3021]

Boundary conditions for a clamped end of a beam

A Labuschagne

Department of Mathematics
University of Pretoria
anneke.labuschagne@up.ac.za

It was realized as far back as the 19th century, that the Euler-Bernoulli model for the transverse vibration of a beam is flawed. In 1921 Timoshenko proposed an alternative model consisting of a system of two wave equations. It is generally recognized that this is a better model. Duva and Simmonds [1] however claim that for the first eigenfrequency of the cantilever beam, the Timoshenko model provides a correction in the wrong direction. Careful consideration of a clamped end of a beam leads to the conclusion that the boundary conditions for the two models are not compatible. This fact suggests that the boundary conditions for a clamped end of a Timoshenko beam need to be improved. We propose a new boundary condition and discuss the results obtained.

References

[1.] J M Duva and J G Simmonds, The usefulness of elemantary theory for the linear vibrations of layered, orthotropic elastic beams and corrections due to two-dimenstional end effects, *Trans of ASME, Journal of Applied Mechanics*, **58**, 1991, 175 - 183

[Fri, 17:00, Room 3021]

Variable precision floating point considered perilous

Dirk Laurie

Department of Mathematics, University of Stellenbosch
dpl@sun.ac.za

Computer packages (Mathematica, Maple, Pari-GP and many others) that offer symbolic algebra typically also offer extended arithmetic abilities such as "infinite precision" integer and rational arithmetic (i.e. exact arithmetic, limited by your computer's memory size and speed rather than by its architecture) and "arbitrary precision" floating point (i.e. not exact, but you can decide in advance how many digits must be carried, again limited only by memory and speed). For reasons of efficiency, arbitrary precision is usually quantized as a certain number of words.

Many of these systems combine arbitrary precision floating point with some sort of significance arithmetic. When the difference of two numbers can be exactly represented using fewer words in the mantissa than the operands themselved had, this is done; the result is deemed from that point onwards to be known only to the number of words carried, on the presumption that the other digits were "lost by cancellation". For example, if later such a number is multiplied by a higher-precision number, the result is considered to have the precision of the lower-precision number only, and the extra digits in the product are discarded on the grounds that they are spurious.

Much of the time this behaviour is helpful, alerting the user to possible numerical instability of the computational method used. But sometimes it is a nuisance. In this talk we give some examples where, because of the pernicious effects of significance arithmetic, the final result is much less precise than it should have been, and offer practical advice on how to live with variable-precision floating point.

[Thur, 08:30, Room 3021]

A Prototype Four-Dimensional Galerkin-Type Integral

J. N. Lyness

Mathematics and Computer Science Division
Argonne National Laboratory, Argonne, IL 60439 U.S.A.
and
School of Mathematics
University of New South Wales
Sydney, NSW 2052 Australia
lyness@mcs.anl.gov

When applying boundary Galerkin methods to hypersingular integral equations defined on surfaces, many four-dimensional integrals over a hypercube have to be evaluated. Some of these integrals, those difficult to compute, involve integrands having singular behaviour at vertices and along "edges". The number of these integrals is of order n, where n denotes the dimension of the Galerkin matrix. This number may be quite high, let us say of order one million.

Here, I treat only one such integral in order to illustrate, in an anecdotal manner, how occasionally an approach involving extrapolation can be cost-effective.

This is

$$I_4 f = \int_{[0,1]^4} \left\{ (x_1 - x_2)^2 + (y_1 - y_2)^2 \right\}^{-1/2} dx_1 dy_1 dx_2 dy_2.$$

This work was supported in part by the Mathematical, Information, and Computational Sciences Division subprogram of the Office of Advanced Scientific Computing Research, U.S. Department of Energy, under Contract W-31-109-ENG-38.

[Thur, 11:30, Room 3021]

Majority voting and tournaments

József Mala

Corvinus University of Budapest, Hungary
jozsef.mala@uni-corvinus.hu

We consider a finite set of voters and a finite set of alternatives, called A. The preferences of the voters are linear orders on A and an m-tuple of linear orders (m is the number of voters) is called a profile. A profile induces the so-called majority relation on A:

$$aMb \text{iff at least half of the voters prefer } a \text{ to } b.$$

The well known result of McGarvey in social choice theory says that if T is a tournament on A then there exists a profile on A (with sufficiently many voters) such that the corresponding majority relation is T.

If λ is between 0 and 1 then the M_λ relation is defined by:

$$aM_\lambda b \text{iff at least a } \lambda\text{-proportion of voters prefer } a \text{ to } b.$$

It can be proved that for each $\frac{1}{2} < \lambda < 1$ there exists a tournament T such that it does not coincide with the M_λ of any profile. In other words, if $\lambda(T)$ is the least upper bound of the λ such that $T = M_\lambda$ (by McGarveys theorem $\lambda(T)$ is always greater than $\frac{1}{2}$) then for each λ strictly between $\frac{1}{2}$ and 1 there exists a tournament T with $\lambda(T) < \lambda$ (in fact, most of the tournaments are such). The $\lambda(D)$ can be defined for every oriented graph D. The following extension of the above results is obtained: for each $\frac{1}{2} < \lambda < 1$ there exists an oriented graph D with $\lambda(D) < \lambda$ containing only large cycles. We can also obtain bounds for $\lambda(T)$ if T is a composite tournament.

Open question: is it true that in a society, where the (linear) preferences are randomly and uniformly distributed, the probability that $\lambda(M)$ is close to $\frac{1}{2}$ is (M is the majority relation) nearly 1 if the society has many voters and many alternatives ?

[Wed, 16:00, Room 3018]

3D Tracking between Satellites, using monocular Computer Vision

Francois Malan, W.H. Steyn and B.M. Herbst

Department of Electrical and Electronic Engineering, University of Stellenbosch
fmalan@gmail.com

This thesis investigated methods for estimating relative 3D position and pose from monocular image sequences. The intended future application is of one satellite observing another, when flying in close formation. The ideas explored build on methods developed for camera calibration and Kalman filter-based Structure from Motion (SfM). The applicability of the Extended Kalman Filter is compared to the Unscented Kalman Filter, and results shown for simulated as well as experimental trails.

[Fri, 12:00, Room 3018]

Long term Dynamics of HIV disease progression with a non-sterilizing vaccine

James Malm and Gareth Witten

African Institute for Mathematical Sciences, Muizenberg
and
Department of Mathematics and Applied Mathematics, University of Cape Town
james@aims.ac.za, gareth@maths.uct.ac.za

We developed an age-structured epidemiological model to simulate the long-term impact of a disease modifying HIV vaccine in Southern Africa. We adopted a previously published model [Davenport, et al, 2004] for a non-sterilizing vaccine for HIV. The model incorporates intra-host dynamics of infection, transmission rate and host mortality that depends on viral load. Also incorporated in the model are the possible evolution and transmission of vaccine escape mutants virus, a finite duration of vaccine protection and changes in risky behaviour. Differential equations are used to model the transitions between population subgroups defined by sex, age, vaccination status and duration of infection. We used the model to investigate the long-term outcome of a disease modifying vaccine and employ sensitivity analysis to quantify effects of our inadequate knowledge of various parameters.

[Wed, 14:00, Room 2016]

Liquidity Effects and the Pricing of Financial Derivatives

Eben Mare

University of Pretoria
eben.mare@up.ac.za

The classical Black-Scholes analysis for the pricing of financial derivatives assumes no liquidity constraints and no transaction costs. This assumption implies free trading in an underlying security when dynamically replicating derivative securities. We present an analysis showing the effects of practical liquidity constraints when creating dynamic hedges to replicate derivative securities.

[Fri, 09:00, Room 3021]

Applications of Lie point symmetries in continuum mechanics

David Mason

University of the Witwatersrand, Johannesburg, South Africa
dpmason@cam.wits.ac.za

Problems in continuum mechanics are formulated as differential equations. It is illustrated how the Lie point symmetries of the differential equations can be applied to generate solutions.

Lie point symmetries give a systematic way of deriving a solution. No assumption on the form of the solution is required. This is illustrated by considering the free jet and the wall jet. Both of these problems contain a hidden invariant.

It is outlined how Lie point symmetries can be used to derive the nonlinear superposition principle for the Ermakov-Pinney equation. Nonlinear radial oscillations of a thin-walled Mooney-Rivlin cylindrical tube are described by the Ermakov-Pinney equation. It is shown how the differential equation to next order in tube thickness can be transformed to the Ermakov-Pinney equation and the nonlinear superposition principle extended to the next order of tube thickness.

Lie point symmetries can be used in mathematical modelling, for instance in problems containing an unspecified function. The unspecified function may be determined for a group invariant solution to exist and exact analytical solutions derived. This is illustrated by considering the spreading of a thin liquid drop on a horizontal plane with suction or blowing at the base and also the spreading of a thin liquid drop with slip. The unspecified functions are the normal and tangential velocity components at the base.

Finally an industrial problem is discussed. The fracturing of rock with ultra high pressure water, instead of by explosives, can be formulated as a nonlinear diffusion equation for the thickness of the crack. It is illustrated how the Lie point symmetries of the nonlinear diffusion equation can be used to reduce the problem to an ordinary differential equation and an expression for the length of the crack.

[Thur, 09:00, Room 3021]

Nonstandard quadratures of Gaussian type

Gradimir V. Milovanovic

University of Nis
Nis, Serbia
grade@ni.ac.yu

More than hundred years after Gauss published his famous method of approximate integration, which was enriched by significant contributions of Jacobi and Christoffel, there appeared the idea of numerical integration involving multiple nodes (Chakalov, Popoviciu, Turan, Stancu, Ghizzetti, Ossicini, etc.). Such generalized Gaussian quadrature with multiple nodes, beside the values of the function, uses the values of the corresponding derivatives at the nodes, too.

Further extensions, dealing with multiple node Gaussian quadrature rules for so-called Extended Chebyshev Systems, introduced in 1976 by Karlin and Pinkus and investigated later by Barrow, Bojanov, Braess, Dyn, etc. Almost in the same time, Omladic, Pahor and Suhadolc started with some kind of nonstandard quadratures. The basic idea came up during the study of the physical measurement. Namely, instead of the exact value of the physical quantity at the given point, the measurement always gives the average value over some (usually small) interval. From such measured, averaged values of the physical quantity, an approximation for the average over some wider interval can be obtained. In this way, a natural question in numerical integration is if there exists a quadrature formula using the averages instead of the values of the function, which is exact on the certain polynomial space, or even on the polynomial space of the highest possible degree (Omladic, 1992). Such new nonstandard Gaussian quadrature rules are known as Gaussian interval quadratures.

Recently, an important theoretical and constructive progress on this subject has been made by Bojanov, Petrov, Cvetkovic and Milovanovic. The questions of the existence, uniqueness and computation of such quadratures with respect to the classical weight functions are going to be considered in this lecture. Moreover, some other types of linear operators, instead of the average (Steklov) operator, have been investigated, and are going to be addressed in this lecture. We characterize the solution for the nodes and weights in the generalized Gaussian quadrature rules in terms of orthogonality of certain class of polynomials orthogonal with respect to the measure representing the inverse operator which appears in the quadrature formula. A numerical algorithm, dealing with construction, is going to be presented, also.

[Fri, 14:00, Room 3018]

Factors affecting phenotypic switch from CCR5 to CXCR4 coreceptor usage in HIV-1 subtype C and subtype B

T. Mugwagwa and G. Witten

University of Cape Town, Department of Mathematics and Applied Mathematics
and
Stellenbosch Institute for Advanced Study
tendai@aims.ac.za, gareth@aims.ac.za

HIV-1 subtype B and subtype C viral strains have been shown to have different replication kinetics in vitro. Further more immunological and within host environment differences have been suggested to influence the choice of coreceptor usage. We use a mathematical model to determine the factors affecting the delayed or rare coreceptor switch in HIV-1 subtype C infected individuals. The model takes into account the two main target cells for the CXCR4-tropic and CCR5-tropic virus and includes the the lytic and non-lytic immune responses. Simulations and sensitivity analysis (Plackett-Burman sensitivity analysis) of the model predicts that the slow replication kinetics of the subtype C CCR5-tropic virus observed in vitro cannot account for the delay in coreceptor switch. However, the enhancement of the subtype C CCR5-tropic virus replication kinetics by increased immune activation in vivo is predicted to play a major role in the delay. Furthermore, this immune activation may also result in an increase in concentration of cytokines within the host creating an environment that favours the CCR5-tropic virus rather than the CXCR4-tropic virus. As in previous models, we also find that a persistent immune response suppresses the CXCR4-tropic virus to low levels and hence preventing a switch, however, we also find that the lytic immune response, in particular, has a greater role to play in the supression of the CXCR4-tropic virus as compared to the non-lytic immune response.

[Wed, 12:00, Room 3018]

Estimating the pen trajectories of multi-path static scripts using hidden Markov models

Emli-Mari Nel

Department of Electronic and Electric Engineering,
University of Stellenbosch
emnel@dsp.sun.ac.za

Static handwritten scripts are available only as images on documents and by definition do not contain dynamic information. This study is about extracting dynamic information from a static handwritten script, specifically the sequence of pen positions that created the script. We assume that a dynamic representative of the static image is available (a different version typically obtained during an earlier registration process). A Hidden Markov Model (HMM) of the static image is compared with the dynamic representative to extract the dynamic information from the static image.

[Thur, 16:00, Room 3018]

Comparison of the spreading of a non-Newtonian fluid for two power-law rheologies

SN Neossi Nguetchue, E Momoniat and S Abelman

Center for Differential Equations,
Continuum Mechanics and Applications,
School of Computational and Applied Mathematics,
University of the Witwatersrand
sneossi@cam.wits.ac.za

We investigate the two dimensional flow induced by a localized insoluble surfactant on a thin power-law fluid. For comparison, we use two power-law models of the stress tensor. Lubrication theory is employed to derive equations that describe the evolution of the thin film thickness and surfactant concentration. A linear surface- tension equation of state describes the relationship between the surfactant concentration and the surface-tension. Numerical results are given. Key words: Lubrication theory, power-law, surface-tension, surfactant concentration.

[Thur, 16:30, Room 3018]

Numerical solutions for singularly perturbed equations of kinetic theory

Nabendra Parumasur, Jacek Banasiak and Jan Kozakiewicz

University of KwaZulu-Natal, Howard College Campus
parumasurn1@ukzn.ac.za

We consider the numerical solution of various equations occurring in kinetic theory, including the linear Boltzmann equation of semiconductor theory under the influence of a weak external field. The numerical algorithm is based on the compressed asymptotic procedure, which provides a general method for the unified treatment of the bulk approximation and the initial layer occurring in conventional perturbation analysis. The procedure is well suited for dealing with non-equilibrium initial data by employing a special technique for handling the initial layer. Various derivations are provided and the numerical experiments, performed in Matlab, provide a good motivation for using the method in a wide range of applications.

[Wed, 16:30, Room 2016]

A new way to design fitted operator finite difference methods for the numerical solution of singular perturbation problems

Kailash C. Patidar and Jean M.-S. Lubuma

University of Pretoria
kailash.patidar@up.ac.za

We consider some linear and nonlinear singular corresponding to the initial as well as boundary value problems. These are the problems in which a very small positive parameter is multiplied to the highest order derivative term in the differential equation. Most of the classical methods fail in giving reliable numerical results when this parameter approaches to zero. Out of the many attempts made so far, we briefly present some of them, which form the basis of the so-called fitted operator finite difference methods (FOFDMs). We then demonstrate a new way to design these FOFDMs which is much easier to construct than the well-known methods. This new method, which will be termed as "non-standard finite difference method (NSFDM)", basically takes advantage of the knowledge of the exact schemes (if they can be constructed). However, in context of more general problems, we will further show that the presence of an exact scheme is not always mandatory so infact we will have much simpler ways to design the schemes for the more general problems. By means of some theoretical and numerical experiments we will show that these schemes preserve significant properties of the governing differential equations and thus give us the reliable numerical results. The numerical results are shown to be parameter uniform.

[Thur, 17:00, Room 3018]

Numerical Study of rotating flow with slip condition

R. Ravindran

University of Witwatersrand
rravi@cam.wits.ac.za

The solution of the rotating flow of Non-Newtonian fluids subject to wall slip is a special challenge. Here the steady flow of an incompressible third-grade fluid on a porus plate is studied. Numerical solution for the governing highly non-linear problem is obtained using MATLAB. The effect of the Non-Newtonian characteristics, slip, rotation parameter and the Suction or Injection velocity at the surface of the plate on the velocity is presented and discussed.

[Thur, 17:00, Room 3021]

The Highlight Conjecture in LULU -Transforms

C.H. Rohwer and J.P. Harper

Department of Mathematics, University of Stellenbosch
and
Electronic Developement Hause (EDH)
chr@sun.ac.za

At the previous Sanum conference we demonstrated a remarkable property of Lulu-decompositions of an image. In a practical problem of the automatic detection of a golf ball on a green, it was found that a simple procedure of detection could be demonstrated effectively by just increasing the amplitude of the pulses identified as part of the golfball. The golfball simply became luminous , without any distortion to the surrounding features. This was not predictable by theory, but is now.

[Wed, 11:30, Room 3018]

Introduction to pattern recognition

Ludwig Schwardt

Department of Electric and Electronic Engineering, University of Stellenbosch
schwardt@sun.ac.za

Pattern recognition is the use of algorithms to extract and exploit similarities and differences in data sets. Its techniques have been successfully applied in such varied fields as speech recognition, image recognition, biometrics, bio-informatics and financial modelling. This talk will introduce the basic concepts of pattern recognition, with emphasis on pattern classification. In the process we will highlight two popular statistical models in this field, namely Gaussian mixture models (GMMs) and hidden Markov models (HMMs). GMMs are widely used to model static (unordered) feature data, while HMMs allow the modelling of time dependencies in data.

[Wed, 15:00, Room 3018]

Higher-order HMM training based on information theory

Ludwig Schwardt

Department of Electric and Electronic Engineering, University of Stellenbosch
schwardt@sun.ac.za

A higher-order hidden Markov model (HMM) models longer time dependencies than the standard first-order HMM, by careful construction of its state topology. This is useful when the relevant patterns in the data are spread out over larger time spans than the low-level features themselves, as in the case of spoken language recognition.

We show how information-theoretic methods provide a convenient way to construct a higher-order HMM from data. The prediction suffix tree (PST) is first introduced as a compact representation of a class of Markov chains. It is then used to train the HMM topology from data, by embedding it in the expectation-maximisation (EM) algorithm. Results are shown on the task of language recognition.

[Wed, 14:30, Room 2016]

An extreme, computable dynamical system

David Sherwell

University of the Witwatersrand, Johannesburg
sherwell@cam.wits.ac.za

In chaotic dynamical systems, orbits are computable but not feasibly computable. Thus for fixed output precision, accuracy of input data must increase linearly with length of orbit (or time). We are interested in computation of the formulae for continuous sheets of particles in a Sinai billiard; the orbit dynamics is isomorphic to a Bernoulli shift and is chaotic. Then the number of accurate digits of input data must increase exponentially with time. This is superconvergence applied to fully developed chaos, to be compared with its application in the KAM theorem of the proof of invariant tori in sufficiently weakly nonlinear dynamics.

[Wed, 11:30, Room 3021]

On Stable Integration of Stiff Ordinary Differential Equations with Global Error Control

SK Shindin and G. Yu Kulikov

University of the Witwatersrand, Johannesburg
sshindin@cam.wits.ac.za

In the paper we design an adaptive numerical method to solve stiff ordinary differential equations with any reasonable accuracy set by the user. It is a two-step second order method possessing the A-stability property on any nonuniform grid derived by Dahlquist et al. This method is also implemented with the local-global step size control developed earlier by Kulikov and Shindin to construct the appropriate grid automatically. It is shown that we are able to extend our technique for computation of higher derivatives of fixed-coefficient multistep methods to variable-coefficient multistep methods. We test the new algorithm on problems with exact solutions and stiff problems as well, in order to confirm its performance.

[Thur, 11:30, Room 3018]

Modelling of Generalised Newtonian Fluid flow in Porous Media

G.J.F. Smit

Department of Applied Mathematics Stellenbosch University
fsmit@.sun.ac.za

The flow through porous media is of interest to many fields of engineering and science such as tertiary oil recovery, soil mechanics and filtration. Deterministic geometric pore-scale models, introduced during the last decade for the prediction of Newtonian flow phenomena in homogeneous porous media, were very successful regarding quantitative comparison with experimental results. However, the fluids increasingly used in commercial applications, including the chemical and mechanical industries, exhibit non-Newtonian behavior, in the sense that the shear stress is no longer proportional to the shear rate.

This paper therefore addresses subsequent efforts to enhance the capabilities of the models by application to the seepage of non-Newtonian flow through various kinds of porous microstructures. The goal is to minimize empirical input by using only fundamental physical properties of the particular fluids and porous microstructures. Careful definitions of apparent viscosities and interstitial Reynolds numbers provide a powerful deterministic method for the analysis and prediction of such phenomena.

The model is derived by volumetrically averaging the equations of motion over an arbitrary two-phase system of stationary solids and a traversing fluid. Closure for particular media is obtained by using a formerly introduced rectangular representation of the pore space morphology. In the very low Reynolds number regime fully developed laminar flow is assumed and the shear rate dependency of the apparent viscosity is incorporated through the wall shear stress by means of generalized Newtonian viscosity models. In the higher laminar Reynolds number regime the inertial effects are quantitatively predicted through reference to local flow recirculation within the pores on the lee side of the solid material.

Comparison of the model results with experimental data from literature is provided and shown to be in good agreement. The availability of non-empirical models yielding satisfactory predictive properties considerably enhances the scientific basis of analyses and large scale computational efforts. One of the predominant features is that the predictive equations span the total porosity range from zero through unity as well as the full Reynolds number range for laminar flow, i.e. $0 \leq Re \leq 1000$.

[Thur, 12:00, Room 3021]

Optimization-based methods for the determination of cable forces of over-constrained planar tendon-driven parallel manipulators

Jan A. Snyman and Alex M. Hay

Department of Mechanical and Aeronautical Engineering,
University of Pretoria
jan.snyman@up.ac.za

In this paper new methodologies for determining the tension distribution, and optimal configurations, of tendon-driven planar parallel manipulators are presented. Tendon-driven parallel manipulators are characterized by the use of cables in place of the linear actuators used in most parallel manipulators. Three separate but inter-related topics are examined, and methodologies for addressing them are proposed. The first topic addressed is the determination of cable forces for over-constrained tendon-driven planar manipulators, which is necessary in order to address the second topic, namely the development of a methodology for workspace determination of tendon-driven manipulators. The final topic examined is the dimensional synthesis of tendon-driven planar manipulators for a large dextrous workspace. The numerical methodologies developed here have potential for easy application to more complex spatial cases.

[Thur, 10:30, Room 3021]

Convection-diffusion problems and their numerical solution

Martin Stynes

National University of Ireland, Cork, Ireland
m.stynes@ucc.ie

Convection-diffusion problems arise in the modelling of many physical processes. Their typical solutions exhibit boundary and/or interior layers. Despite the linear nature of the differential operator, these problems pose still-unanswered questions to the numerical analyst.

This talk will discuss the nature of solutions to convection-diffusion problems in one and two dimensions, the inadequacy of classical numerical methods in this context, and the leading numerical techniques (including SDFEM and Shishkin meshes) in current use for these problems.

[Thur, 14:30, Room 3018]

Interstitial Modelling of Intermediate Reynolds Number Flow Through a Prismatic Bundle

Luther Terblanche

Department of Applied Mathematics, University of Stellenbosch
luther@dip.sun.ac.za

It is experimentally accepted that, during flow through porous media, the relation between the pressure gradient and velocity is non-linear for intermediate Reynolds numbers. It is also accepted that the non-linearity is due to the dominance of inertial forces compared to viscous forces. However, derivations of analytic expressions for this relation is still an important field of research.

In this presentation interstitial flow phenomena in the so-called Forchheimer regime are modelled within a Rectangular Representative Unit Cell. Two analytical expressions for the pressure gradient are presented. Firstly, an analytical approximation of the pressure gradient over a single two-dimensional square is attempted by relating the interstitial flow through a prismatic bundle as flow in an expanding tube. The second relation utilizes the Bernoulli equation for flow around a square prism and requires an estimation of the interstitial velocity in different flow channels. In both cases the commercial Computational Fluid Dynamics code FLUENT is used to aid the predictions as well as to verify the validity of the assumptions made during the modelling.

[Fri, 08:30, Room 3021]

Tippy Top

Tadashi Tokieda

Cambridge University
tokieda@aims.ac.za

When a convex body spins in frictional contact with a floor, it tries to raise its centre of gravity; often it will even flip upside down. This weird dynamics, called 'tippy top', has been analysed by many people for over a century. In this talk I will perform experiments, point out important bits of phenomenology that have gone unnoticed, and present a simple theory that calculates quantities of prime physical interest (e.g. flip-over time) that were not handled in these past works.

[Wed, 17:00, Room 3021]

A quadratic eigenvalue problem for a system of differential equations

A J van der Merwe

Department of Mathematics
Cape Peninsula University of Technology
vandermerwea@cput.ac.za

We consider a quadratic eigenvalue problem for a system of differential equations:

$$\begin{aligned} \mu^2 u &= -u'' + \phi', \\ \mu^2 \phi &= -\frac{1}{\gamma}\phi'' - \alpha u' + \alpha\phi, \end{aligned}$$

with boundary conditions

$$\begin{aligned} u(0) = u(1) = \phi'(0) &= 0, \\ \phi'(1) + k\mu\phi(1) &= 0. \end{aligned}$$

It is important to note that the eigenvalue μ appears in the boundary conditions.

The effect of boundary damping on a cantilever Timoshenko beam has received much attention. A similar quadratic eigenvalue problem (with different boundary conditions) arises in these investigations. The properties of the spectrum are of significance for the stabilization and control of such a beam. It has been shown, empirically and theoretically, that the spectrum is discrete and countable and split into two disjoint sets.

The present eigenvalue problem arises for boundary damping of a Timoshenko beam that is pinned at the endpoints. The two-banded structure of the damped spectrum is retained. In this case the eigenfunctions of the eigenvalue problem for the associated undamped beam can be obtained in closed form. The two-banded structure of the damped spectrum can be explained from the properties of the eigenfunctions of the undamped model.

[Wed, 16:30, Room 3018]

Automated stratigraphic classification and feature detection from images of borehole cores

Stefan van der Walt

Department of Electronic and Electic Engineering,
University of Stellenbosch
stefan@sun.ac.za

In order to extract South Africa's rich mineral resources, mining activities must be accurately directed. Geologists' knowledge is applied to assist mining companies in locating the most profitable ore. Boreholes are an indispensable aid in this regard: the resulting cores reflect the nature of rock layers deep beneath the earth's surface.

It is, however, a monumental task to study and classify individually the kilometers of core produced. In completion of my master's degree, I faced the challenge of automating this task.

I shall discuss how wavelet theory and other modern image processing techniques were applied to overcome this problem.

[Wed, 16:00, Room 3021]

Mild solutions of second order hyperbolic partial differential equations

N F J van Rensburg

Department of Mathematics and Applied Mathematics
University of Pretoria
nvrens@scientia.up.ac.za

With second order hyperbolic partial differential equations may be associated an ordinary differential equation for a function with values in some Banach space. A classical solution of this (abstract) differential equation needs not be a classical solution of the partial differential equation. Weaker solutions are possible as the semigroup associated with the abstract differential equation may not be differentiable. If this is the case, it is said that a mild or weak solution exists.

Mild solutions are not merely of academic interest. Modelling complex mechanical systems, one may easily create a model problem with merely a mild solution and this has implications for numerical computations.

It is natural to investigate the physical significance – if any – of mild solutions. We consider the wave equation as it is the simplest second order hyperbolic partial differential equation. Here it is easy to construct solutions with different "degrees of smoothness".

[Fri, 16:00, Room 3021]

A Satellite Survey of Cloud Cover and Water Vapour over Candidate Telescope Sites

Ruby van Rooyen

E^2 Consultants, Observatory, Cape Town
rooyen@saao.ac.za

A number of new initiatives to build next-generation extremely large telescopes (ELT) are under way and many potential observatory sites of high quality may exist in Africa.

The performance of large telescopes at optical and infra-red wavelengths is critically dependent on atmospheric cloud cover and water vapour. Therefore, in terms of the global search for ELT sites, a study of cloud conditions over selected areas and at candidate telescope sites within these areas will be an essential component.

Both ground-based and satellite observations are used to quantify cloud cover and water vapour at telescope sites:

Ground-based observations provide ground-truth for a given site provided the method of observation is reliable. These sites are usually existing observatories where cloud cover is determined using some instrument or a human observer. However, comparable observations are usually not available at potential telescope sites and making similar ground-based measurements at a large number of different sites over a suitably long period of time is a logistically impossible exercise.

Meteorological satellites provide a consistent measurement of cloud cover and water vapour over a wide field of view. This allows for a quantitative aerial mapping of relevant cloud cover and water vapour parameters so that a reliable comparison of regions and sub-regions can be made. Moreover, most of the meteorological satellites observing different areas of the globe are equipped with the same instrumentation. This means that areas and sites observed by two or more satellites can be reliably compared. Satellite data archives also permit a comparison of observing conditions over an extended period (5 years or more).

[Fri, 11:30, Room 3021]

Multidimensional Padé techniques at work in shape reconstruction

Brigitte Verdonk and Annie Cuyt

Department of Mathematics and Computer Science, University of Antwerp
brigitte.verdonk@ua.ac.be

The problem of reconstructing a function and/or its domain given its moments is encountered in many areas. Several applications from diverse areas such as probability and statistics, signal processing, computed tomography and inverse potential theory (magnetic and gravitational anomaly detection) can be cited, to name just a few. We expound on some of these applications in a bit more detail. Tomographic (line integral) measurements of a body of constant density can be converted into moments from which an approximation to its boundary can be extracted. Measurements of exterior gravitational or magnetic field induced by a body of uniform mass or magnetization, can be turned into moment measurement from which the shape of the region may be reconstructed. Measurements of thermal radiation made outside a uniformly hot region can yield moment information, which can subsequently be inverted to give the shape of the region. Although the reconstruction of a shape from its Radon transform is well-understood, the reconstruction of a shape from its moments is a problem that has only partially been solved. For instance, when the object is a polygon or when it defines a quadrature domain in the complex plane, it has been proved that its shape can exactly be reconstructed from the knowledge of its moments. Both results deal with particular 2-dimensional shapes. For general n-dimensional shapes no inversion algorithm departing from the moments, is known so far. We explain how the open problem can be tackled successfully.

[Wed, 09:00, Room 3021]

Numerical methods for fitting models to uncertain data

G. Alistair Watson

Department of Mathematics,
University of Dundee, Scotland
gawatson@maths.dundee.ac.uk

A review is given of numerical methods for fitting models to uncertain data, where increasing levels of information about the uncertainty are exploited. The emphasis is on the use of least squares. We will start from the conventional least squares problem, where errors are assumed to be only in the values of the dependent variable. This is generalised to the case where there are errors in all variables (total least squares) and then to the case where there are known bounds on the errors, leading to a treatment of robust counterparts of the least squares problem.

Most attention has been given to models which are linear in the free parameters. We also consider here nonlinear models. We also examine how the ideas extend to criteria other than least squares.

[Fri, 16:30, Room 3021]

Numerical Inversion of the Laplace Transform with Application to Fractional Differential Equations.

André Weideman

Department of Applied Mathematics, University of Stellenbosch
`weideman@dip.sun.ac.za`

The Laplace Transform is a classical technique for solving linear differential equations. In most applications, however, the success of the method hinges on our ability to compute effectively the inverse transform. One of the most efficient methods for this purpose is Talbot's method. It consists of numerically integrating the Bromwich integral on a special contour by means of the trapezoidal rule. In this talk we discuss an alternative parabolic contour with some attractive features, including the property that it can be optimised for accuracy very easily.

We shall present examples from the field of fractional differential equations, an area of research that is becoming increasingly important. In particular, we shall solve (a) the Bagley-Torvik equation, a fractional ODE that arises in materials science, and (b) a fractional PDE analogue of the heat equation, which models sub-diffusion.

(This talk is based on joint work with Nick Trefethen, Oxford University, and Kevin Burrage, University of Brisbane.)

[Thur, 15:00, Room 3018]

On the Hydrodynamic Permeability of Granular Porous Media

S. Woudberg and J.P. du Plessis

Department of Applied Mathematics, University of Stellenbosch
woudberg@sun.ac.za

Granular porous media are found frequently in nature such as sand and certain rock formations like sandstones. The problem posed is usually to find the pressure drop for a certain discharge velocity or vice versa. A rectangular Representative Unit Cell (RUC) model is introduced that leads to reasonable quantification of parameters for a packed bed of spherical particles. It provides a prediction for the hydrodynamic permeability in terms of the porosity. Various staggered arrays, namely, over-staggered, fully staggered and regular (unstaggered) arrays, are considered and through the application of volume partitioning, a model is presented for the arrays of different staggeredness. By taking the average of one fully staggered array and two unstaggered arrays, a generalized RUC model for an isotropic granular medium is introduced. The isotropic RUC model yields a theoretical derivation of the empirical Carman-Kozeny equation for low Reynolds number flow. Fully saturated water motion through sand and sandy soils may be predicted straightforwardly with the equations derived. Because of the deterministic nature of the model, adaptations for spherical cases are easily performed. Seepage through very low porosity rock formations is an example of a natural phenomenon which can be analyzed satisfactorily with small adaptations to the model presented.

[Fri, 14:00, Room 3021]

Solving structured linear systems in the context of adaptive modelling

XiangLan Yang, Annie Cuyt, And Brigitte Verdonk

Department of Mathematics and Computer Science, University of Antwerp,Belgium
xianglan.yang@ua.ac.be

When fitting an analytic model to data, the resulting $S \times S$ linear system of equations expressing the conditions imposed on the model's parameters is often structured. Polynomial interpolation leads to a Vandermonde system, rational interpolation to Cauchy-Vandermonde, rational approximation to Toeplitz or Hankel systems, and least squares approximation to normal equations. To measure structure in a matrix, the concept of displacement rank was introduced by Kailath, Kung and Morf almost 20 year ago.

The displacement rank of a matrix A is defined as the rank of the matrix

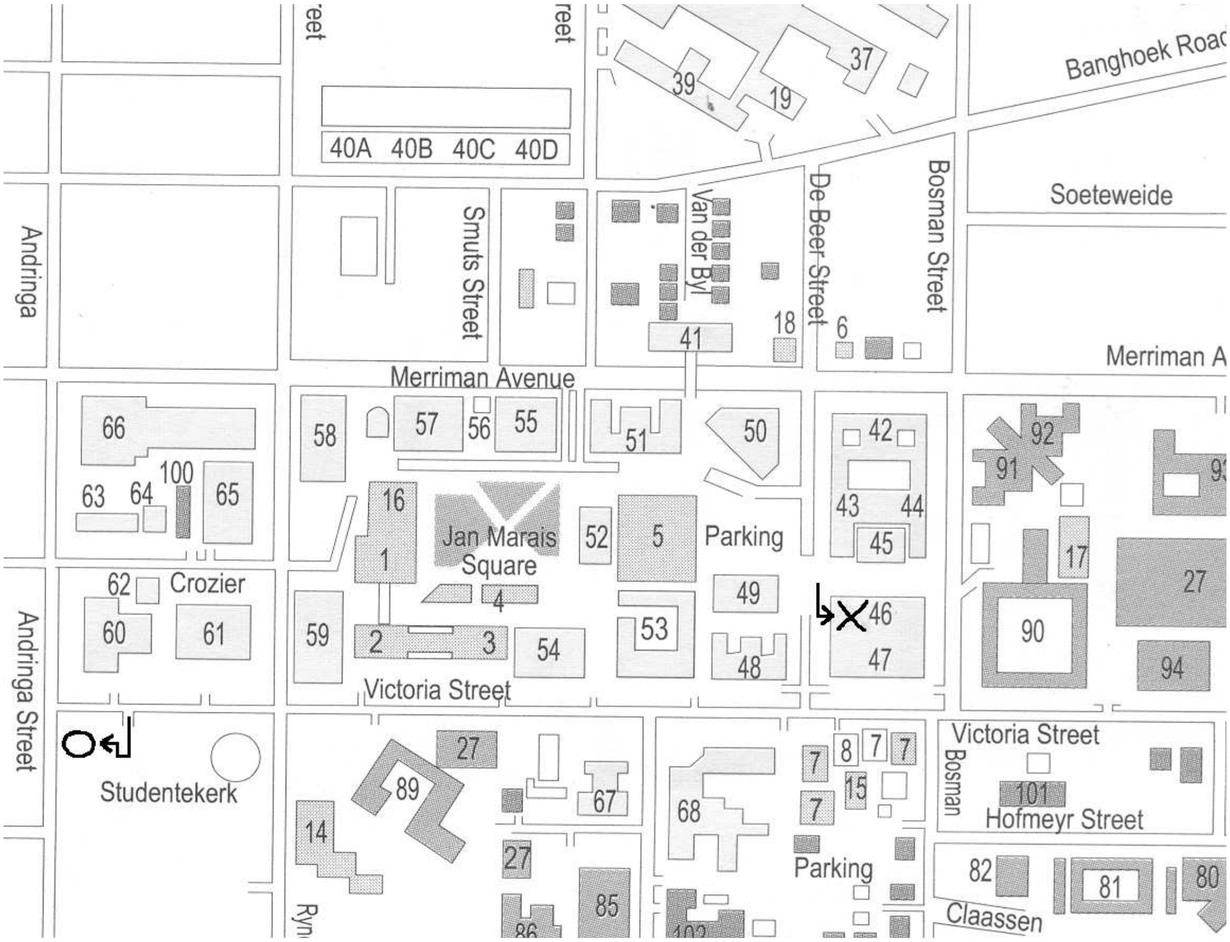
$$L_1 A L_2 - R_1 A R_2 = GB$$

where suitably chosen matrices $L_{1,2}$ and $R_{1,2}$ are called the left and right displacement operators. The purpose of the displacement operators is to reduce the rank of A to as little as possible and generate all the information contained in the matrix A from the factors G and B, which are respectively of size $S \times \alpha$ and $\alpha \times S$ where α is the displacement rank of A and S is its size. Subsequently cheap techniques for the LU factorization of A can be used, with order of complexity αS^2 instead of S^3.

We present an introduction to these techniques, and show how they can be generalized to a multidimensional setting, and how they can be combined with updating and downdating of the model being fitted. The latter usually involve bordering or block bordering. Dedicated bordering techniques for structured matrices need to be developed, that allow to only border the generators G and B of the matrix $L_1 A L_2 - R_1 A R_2 = GB$.

Name	**Surname**	**Affiliation**	**Email**
Shirley	Abelman	University of the Witwatersrand	abelman@cam.wits.ac.za
Mohammed	Altaj	University of Cape Town	mohammed@aims.ac.za
Bayan	Amin	African Institue for Mathematical Sciences (AIMS)	bayanhk@hotmail.com
Jacek	Banasiak	University of KwaZulu-Natal	banasiak@ukzn.ac.za
Mapundi Kondwani	Banda	University of KwaZulu-Natal	bandamk@ukzn.ac.za
Nigel	Bishop	UNISA	bishont@unisa.ac.za
Willie	Brink	University of Stellenbosch	whbrink@dip.sun.ac.za
John	Butcher	University of Auckland, New Zealand	butcher@math.auckland.ac.nz
Francois	Cilliers	University of Stellenbosch	fcilliers@dsp.sun.ac.za
Maret	Cloete	University of Stellenbosch	mcloete@sun.ac.za
Daniel	Cunliffe	University of Stellenbosch	cunliffe@sun.ac.za
Annie	Cuyt	University of Antwerp	Annie.Cuyt@ua.ac.be
Pierre	de Beaudrap	Stellenbosch Institute for Advanced study	pdebeaudrap@yahoo.fr
Frikkie	De Beer	Necsa	fdebeer@necsa.co.za
Johan	de Villiers	University of Stellenbosch	jmdv@sun.ac.za
Deter	de Wet	University of Stellenbosch	deter@sun.ac.za
Dirk	Deschrijver	University of Antwerp	dirk.deschrijver@ua.ac.be
Guy Blaise	Dongmo	University of Stellenbosch	dongmo@sun.ac.za
Prieur	du Plessis	University of Stellenbosch	jpdp@sun.ac.za
Johan	du Preez	University of Stellenbosch	dupreez@dsp.sun.ac.za
JP	du Toit	University of Stellenbosch	
Britt	Halvorsen	Telemark University College and Telemark Technological R&D	Britt.Halvorsen@hit.no
JP	Harper	EHD	
Wouter	Hendrickx	University of Antwerp	wouter.hendrickx@ua.ac.be
Ben	Herbst	University of Stellenbosch	herbst@sun.ac.za
Karin	Hunter	University of Stellenbosch	karin@sun.ac.za
Emmerentia	Jacobs	University of Stellenbosch	ejocobs@sun.ac.za
P	Kaelo	University of the Witwatersrand	pkaelo@cam.wits.ac.za
Abdul Hamid	Kara	University of the Witwatersrand	kara@maths.wits.ac.za
Gennady	Kulikov	University of the Witwatersrand	gkulikov@cam.wits.ac.za
Anneke	Lasbuschagne	University of Pretoria	anneke.labuschagne@up.ac.za
Dirk	Laurie	University of Stellenbosch	dpl@sun.ac.za
James N	Lyness	Argonne National Laboratory IL USA	lyness@mcs.anl.gov
Deneys	Maartens	iThemba LABS	dsm@tlabs.ac.za
Jozsef Mala	Mala	Corvinus University of Budapest	jozsef.mala@uni-corvinus.hu
Francois	Malan	University of Stellenbosch	fmalan@gmail.com

James	Malm	African Institue for Mathematical Sciences (AIMS)	jftmalm@yahoo.com
Eben	Mare	University of Pretoria	eben.mare@up.ac.za
Milton	Maritz	University of Stellenbosch	mfmaritz@sun.ac.za
David	Mason	University of the Witwatersrand	dpmason@cam.wits.ac.za
Gradimir	Milovanovic	University of Nis, Serbia	grade@ni.ac.yu
Tendai	Mugwagwa	University of Cape Town	tendai@aims.ac.za
Neil	Muller	University of Stellenbosch	neil@dip.sun.ac.za
Emli-Mari	Nel	University of Stellenbosch	emnel@dsp.sun.ac.za
Serge N.	Neossi-Nguetchue	University of the Witwatersrand	sneossi@cam.wits.ac.za
Venant	Nyandwi	African Institue for Mathematical Sciences (AIMS)	nyandwi@aims.ac.za
Stephane	Oloungha	University of Stellenbosch	14494604@sun.ac.za
Akwum	Onwunta	University of Stellenbosch	onwunta@sun.ac.za
Rachid	Ouifki	STIAS	ouifki@bondy.ird.fr
Nabendra	Parumasur	University of KwaZulu-Natal	parumasurn1@ukzn.ac.za
Kailash C.	Patidar	University of Pretoria	kailash.patidar@up.ac.za
Helmut	Prodinger	University of Stellenbosch	hproding@sun.ac.za
Darian	Raad	University of Stellenbosch	darianr@sun.ac.za
Ramalingam	Ravindran	University of the Witwatersrand	rravi@cam.wits.ac.za
Carl	Rohwer	University of Stellenbosch	chr@sun.ac.za
Oliver	Salazar Celis	University of Antwerp	oliver.salazarcelis@ua.ac.be
Ludwig	Schwardt	University of Stellenbosch	schwardt@sun.ac.za
David	Sherwell	University of the Witwatersrand	sherwell@cam.wits.ac.za
Sergey	Shindin	University of the Witwatersrand	sshindin@cam.wits.ac.za
Francois	Smit	University of Stellenbosch	fsmit@sun.ac.za
Jan	Snyman	University of Pretoria	jan.snyman@up.ac.za
Martin	Stynes	National University of Ireland	m.stynes.uss.ie
Luther	Terblanche	University of Stellenbosch	luther@dip.sun.ac.za
Tadashi	Tokieda	Cambridge University	tokieda@aims.ac.za
Alna	Van der Merwe	Cape Peninsula University of Technology	vandermerwea@cput.ac.za
Stefan	van der Walt	University of Stellenbosch	stefan@sun.ac.za
Nic	Van Rensburg	University of Pretoria	nvrens@scientia.up.ac.za
Ruby	Van Rooyen	E2 Consultants	rooyen@saao.ac.za
Brigitte	Verdonk	University of Antwerp	brigitte.verdonk@ua.ac.be
Professor Alistair	Watson	University of Dundee, Scotland	gawatson@maths.dundee.ac.uk
Andre	Weideman	University of Stellenbosch	weideman@dip.sun.ac.za
Gareth	Witten	University of Cape Town	gareth@maths.uct.ac.za
Sonia	Woudberg	University of Stellenbosch	woudberg@sun.ac.za
Xiang Lan	Yang	University of Antwerp	xianglan.yang@ua.ac.be



Registration and lectures: 3^{rd} floor of the van der Sterr Building (number 46 on the map; indicated by a cross)

Lunches: The Naked Truth Coffee shop (indicated by a circle) is a comfortable walk down Victoria street

Email and internet: 2^{nd} floor (eastern wing) of Building 39

Transport: to conference dinner leaves from in front of van der Sterr Building (number 46 on the map; indicated by a cross)

Student center: with postal and banking services in the Neelsie (number 5 on the map)