62nd Annual Congress of the South African Mathematical Society

2- 4 December 2019

Program and Abstracts

MaSS
DSI-NRF CENTRE OF EXCELLENCE IN MATHEMATICAL & STATISTICAL SCIENCES

South African Mathematical Society
SAMS

University of Cape Town • iYunivesithi yaseKapa • Universiteit van Kaapstad

The SAMS 2019 Conference is run by UCT's Conference Management Center. During the conference, we can be contacted as follows:

- Belinda Chapman (Coordinator)
  Phone: +27 21 406 6381
  Email: belinda.chapman@uct.ac.za
- Cindy Maree (Registration)
  Phone: +27 21 406 6733
  Email: cindy.maree@uct.ac.za

The SAMS 2019 Local Organizing Committee can be contacted by sending email to `SAMS-2019@uct.ac.za` or phoning the Department of Mathematics and Applied Mathematics (021 650 3191).

The latest version of this document can be found at SAMS2019.uct.ac.za

The open-source LaTeX template, AMCOS_booklet, used to generate this booklet is available at github.com/maximelucas/AMCOS_booklet

Contents

Program

Sunday 1 December

There will be a **cocktail/welcome party and registration function** at 1700 on Sunday 1 December in the lobby of the New Lecture Theatre, located on Upper Campus at the South end of University Avenue (see **map**, p177).

Program key

NLT	New Lecture Theatre
LS1A/B/C/D/E	Leslie Social Sciences Building Lecture Theatre 1A/B/C/D/E
Plenary	Plenary Session
CATL	Special Session on Categories, Algebra, Topology, and Logic (in honour of Professor G.C.L. Brümmer)
FAOT	Special Session on Functional Analysis and Operator Theory
General	General Session
GTC	Special Session on Graph Theory and Combinatorics
LSNDE	Special Session on Lie Symmetries and Nonlinear Differential Equations

Session chairs are indicated in *italics*

Monday 2 December

0730–0830	Registration and coffee (New Lecture Theatre Foyer)					
0830–0900	**SAMS2019 opening and Welcome by the Dean of Science, Professor Maano Ramutsindela** (New Lecture Theatre)					
0900–1000	**Plenary 1: Reddy** (New Lecture Theatre, *Chair: Ebobisse Bille*)					
1000–1020	Coffee (New Lecture Theatre Foyer)					
	CATL 1 *Goswami* NLT		**FAOT 1** *ter Horst* LS1B	**General 1** *Banasiak* LS1C	**GTC 1** *Andriantiana* LS1D	**LSNDE 1** *Ntsime* LS1E
1020–1045	G. Janelidze		Weigt	Munganga	Erwin	Herbst
1045–1110			Schulz	Nyabadza	Babikir	Kubeka
1110–1135	W. Conradie		Lukoto	Moges	Hattingh	Ariyan
1135–1200	Gray		Askes	Dika	Shozi	Mkhize
1200–1225	Dube		Mouton	Djob	Henning	Masemola
1225–1250	Z. Janelidze		Benjamin	Hillebrand	Rapudi	Olivier
1250–1430	Lunch (New Lecture Theatre Foyer)					
1430–1530	**Plenary 2: Mphako-Banda** (New Lecture Theatre, *Chair: Skokos*)					
1530–1600	Coffee (New Lecture Theatre Foyer)					
1600-1700	**Presentation by DST of draft scientometric report** (New Lecture Theatre)					
1700–1830	**SAMS AGM** (New Lecture Theatre)					

Tuesday 3 December

0800–0900	**Plenary 3: Dales** (New Lecture Theatre, *Chair: Mouton*)					
0900–0920	Coffee (New Lecture Theatre Foyer)					
	CATL 2 *Dube* NLT	**CATL 3** *Sabao* LS1A	**FAOT 2** *Kikianty* LS1B	**General 2** *Maharaj* LS1C	**GTC 2** *Wagner* LS1D	**LSNDE 2** *Moleleki* LS1E
0920–0945	Pultr		Pant	Amir	Rivett-Carnac	Khalique
0945–1010			Lee	Bishop	du Preez	Sedjro
1010–1035	Goswami	Hamed	van Zyl	Nikolaev	Alochukwu	Ntsime
1035–1100	Baboolal	Majozi	Rogans	Many Manda	Dankelmann	
1100–1120	Coffee (New Lecture Theatre Foyer)					
	CATL 4 *Dube* NLT	**CATL 5** *Gray* LS1A	**FAOT 3** *Labuschagne* LS1B	**General 3** *Bishop* LS1C	**GTC 3** *Rapudi* LS1D	**LSNDE 3** *Khalique* LS1E
1120–1145	Ntumba	Tlharesakgosi	J. Conradie	Senyange	Ralaivaosaona	Moleleki
1145–1210	Booth	van Niekerk	van der Walt	Messerschmidt	Boshoff	Tshivhi
1210–1235	Rathilal	Olurode	van Amstel	Ratshisindi	Wagner	Mogorosi
1235–1400	Lunch (New Lecture Theatre Foyer)					
1400–1410	**Conference photo** (in front of New Lecture Theatre)					
1410–1510	**Plenary 4: Venkatakrishnan** (New Lecture Theatre, *Chair: Reddy*)					
1510–1530	Coffee (New Lecture Theatre Foyer)					
	CATL 6 *Rathilal* NLT	**CATL 7** *Z. Janelidze* LS1A	**FAOT 4** *van der Walt* LS1B	**General 4** *Munganga* LS1C	**GTC 4** *Dankelmann* LS1D	**General 5** *Sibanda* LS1E
1530–1555	Ssekajja	Chili	Labuschagne	Sekgothe	Dossou-Olory	Dlongolo
1555–1620	Kazeem	Laing	Steyn	Grieshaber	Nkonkobe	~~Magodora~~
1620–1645	Sebogodi	Shaumbwa	~~de Jager~~	Jafari	Archibald	Mburu
1645–1710	Sabao	Broodryk	Wortel	Khumalo	Ncambalala	Monaledi
1710–1735	Agyingi	Ranchod	Kikianty	Marewo	Mokalapa	Rundora
1735–1800	M. Iragi	Muteti		Nkomo	Andriantiana	
1900	**SAMS2019 congress dinner** (Simon's Restaurant, Groot Constantia)					

Wednesday 4 December

0800–0900	**Plenary 5: Pultr** (New Lecture Theatre, *Chair: Baboolal*)					
0900–0920	Coffee (New Lecture Theatre Foyer)					
	CATL 8 *Pillay* NLT	**CATL 9** *Sebogodi* LS1A	**FAOT 5** *Wortel* LS1B	**General 6** *Sanchez-Ortega* LS1C	**General 7** *Ebobisse Bille* LS1D	**General 8** *Rundora* LS1E
0920–0945	Razafindrakoto	Blose	Zinsou	Mpono	Lin	Moremedi
0945–1010	Craig	C. Iragi	Zeelie	Prins	Ali	Noreldin
1010–1035	Hardy	Assfaw	Willie	van Wyk	Nkosi	Oyelakin
1035–1100	Hoefnagel	Rakotonarivo	Duvenhage	de Clercq	Galane	Sithole Mthethwa
1100–1120	Coffee (New Lecture Theatre Foyer)					
	CATL 10 *Pillay* NLT	**CATL 11** *Ntumba* LS1A	**FAOT 6** *Benjamin* LS1B		**General 9** *Ali* LS1D	
1120–1145	Mthethwa	Mahudu	ter Horst		Mhlanga	
1145–1210		Jansen	Jaftha		Mulaudzi	
1210–1235		van der Berg	Naudé		Schönfeldt	
1235–1300			van Straaten			
1300–1400	Packed lunch (collect from New Lecture Theatre Foyer)					
1400–1415	**SAMS2019 closing and presentation of student prizes** (New Lecture Theatre)					

Guidelines for speakers

Each contributed talk is **20 minutes long** followed by 5 minutes for questions. Speakers who wish to use a data projector should bring their presentation as a **PDF** on a flash drive. UCT audiovisual staff will be on site to handle any technical problems.

Prizes for student presentations

Prizes will be awarded for the best student presentations in each session. The names of the winners will be announced at the end of the conference.

Abstracts

Plenary talks

Arens regularity for Banach algebras

H. G. Dales

University of Lancaster
g.dales@lancaster.ac.uk

SAMS Classification: 09 **Plenary Speaker**

The two most important classes of Banach algebras are those of C^*-algebras, essentially the bounded linear operators on a Hilbert space, and those of group algebras, essentially the integrable functions on a locally compact group, such as the real line, with convolution product. The latter are related to Fourier transforms. Both these classes have huge importance in mathe- matics and for applications, especially in physics, and they have a history that stretches over nearly 100 years.

Are these two classes fundamentally different?

One way of showing this is to look at their biduals.

Let A be a Banach algebra, and write A'' for the Banach space that is the bidual of A. Then there are two products, $\Box$ and $\Diamond$, on A'' that make A'' into a Banach algebra; they are the *Arens products*. The algebra A is *Arens regular* (AR) if the two products coincide, and *strongly Arens irregular* (SAI) if this is definitely not the case in a precise sense.

We shall define Banach algebras, their biduals, and the two Arens prod- ucts, give some examples, and explain that all C^*-algebras are (AR) but that all group algebras are (SAI), a basic difference.

Some aspects of the theory of matroids

E. G. Mphako-Banda

University of the Witwatersrand
eunice.mphako-banda@wits.ac.za

SAMS Classification: 14 **Plenary Speaker**

Matroid theory was developed mainly from a deep examination of the properties of independence and dimension in vector spaces. Hence, a matroid is a structure that generalizes the properties of set independence. Matroids are everywhere in mathematics if only we know how to look. Thus, it is not surprising to say that matroid theory provides a unified way to relate finite geometry, graph theory, linear algebra and combinatorics. Moreover, matroid theory borrows extensively from the terminology of linear algebra and graph theory.
In this talk we start by defining a matroid in terms of independent sets and the rank function. We give examples of matroids that we know from vector spaces, finite geometries and graph theory. We discuss some well known properties, operations and established research problems in matroid theory. One such research problem in matroid theory is extending results from graph theory to matroid theory. The biggest challenge in this research problem is that in general there is no real notion of a vertex for a matroid. Nevertheless, some concepts of graphs have been extended successfully to matroids. We demonstrate this extension from graphs to matroids by the notion of vertex-join as q-cones in projective geometries and as H-lifts in Dowling geometries. Furthermore, we discuss one polynomial, the characteristic polynomial which is extended from graphs to matroids. In conclusion, we outline some active research problems in matroid theory.

References:

[1] E. G. Mphako, H-lifts of Tangential Blocks, *Discrete Mathematics*, 285, pp 201-210, (2004).

[2] J. G. Oxley, Matroid Theory, Oxford University Press, Oxford, (1992).

[3] G. P. Whittle, q-lifts of tangential k-blocks, *London Math. Soc.* 39 (2) 915, (1989).

Topology without points:
motivation, some facts, and merits

A. Pultr

Charles University, Prague
pultr@kam.mff.cuni.cz

SAMS Classification: 05

Plenary Speaker

I. Point-free thinking and natural geometry.
Some history:
Roots: Hausdorff, Kuratowski et al.; Wallman, Stone et al.
As understood today: Ehresmann & Benabou,
Isbell, Banaschewski, Dowker & Stauss, Johnstone and others.
The definition: Frame, comparing with the intuition. It leads to a concept substantially more general than (sober) topological space.

Questions. Dont we lose too much information?
Do we need a more general theory?
Does it bring some results more satisfactory then the classical theory?

II. Answers. Reconstruction of a sober space (if one wishes to have the points back). Hofmann - Lawson Duality.
Examples of pleasing results:
Behavior of paracompact locales.
Fine uniformity.
Closed subgroup theorem.
Lindelöf reflection.

And the particularly important feature: Often one does not need the Axiom of Choice where it was classicaly essential: even for instance in compactification is choice-free, the same with completion; compactness of products of compact spaces as well.

Analysis and computation in solid mechanics

D. Reddy

University of Cape Town
daya.reddy@uct.ac.za

SAMS Classification: 13,16,11

Plenary Speaker

Problems in solid mechanics typically take the form mathematically of systems of partial differential equations, inequalities, or as variational problems. Studies of the well-posedness of such problems provide valuable insights into the range of validity of parameters describing material behaviour, and of the models themselves. The development of approximate solutions and accompanying numerical simulations are an essential component of investigations, given the intractability of all but the simplest cases. This presentation will provide an overview of some problems in linear and nonlinear solid mechanics of recent and current interest, with a focus on anisotropic elasticity and elastoplasticity. Key results will be presented on their well-posedness, the development of algorithms for numerical approximations, and the determination of conditions for convergence of such approximations.

Improving the foundations: Early number learning outcomes in South Africa

H. Venkatakrishnan

University of Witwatersrand
hamsa.venkatakrishnan@wits.ac.za

SAMS Classification: 18

Plenary Speaker

The prevalence of concrete unit counting is among the most widely written about phenomena related to primary mathematics learning in South Africa. Several studies have provided evidence of pages filled with one-by-one tally counts for calculations involving whole number operations, an approach that is unwieldy and error-prone. In this context, the Wits Maths Connect-Primary project has worked with teachers on activities and teaching approaches that seek to support learners to move to more efficient approaches. In this lecture, I share the longitudinal outcomes of the Structuring Number Starters intervention, which has gathered evidence of moves, over time, to more efficient calculating approaches among learners in partner primary schools.

Contributed talks

Abstracts are ordered alphabetically by the speaker's last name.

Special Session Organizers

Categories, Algebra, Topology, and Logic
Prof T Dube (University of South Africa)
Dr A Goswami (University of Johannesburg)

Functional Analysis and Operator Theory
Dr R Benjamin (Stellenbosch University)
Prof S ter Horst (North-West University)
Dr M Messerschmidt (University of Pretoria)

General Session
Dr F Ebobisse Bille (University of Cape Town)
Dr T Janelidze-Gray (University of Cape Town)
Prof H Skokos (University of Cape Town)

Graph Theory and Combinatorics
Dr E Andriantiana (Rhodes University)
Prof P Dankelmann (University of Johannesburg)

Lie Symmetries and Nonlinear DEs
Prof CM Khalique (North-West University)
Dr BP Ntsime (University of Johannesburg)

SAMS Subject Classifications

01 Mathematical Logic and foundations
02 Algebra
03 Number Theory
04 Geometry
05 Topology
06 Algebraic geometry
07 Lie groups and representations
08 Real and Complex analysis
09 Operator algebra and functional analysis
10 Probability Theory and Math. Statistics
11 PDE's and dynamical systems
12 ODE's and dynamical systems
13 Mathematical Physics
14 Combinatorics
15 Math. aspects of computer science
16 Computational methods
17 Applications of Math. to the sciences
18 History, teaching of mathematics

Endpoints in T_0-quasi-metric spaces

C.A. Agyingi*

Nelson Mandela University
collins.agyingi@mandela.ac.za

P. Haihambo

University of Namibia
kashitoma@yahoo.com

H.-P.A. Künzi

University of Cape Town
hans-peter.kunzi@uct.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

In his well-known paper dealing with the construction of the injective hull of a metric space Isbell introduced the concept of an endpoint of a (compact) metric space.

In the present talk we introduce similarly the notion of asn endpoint in a (joincompact) T_0-quasi-metric space. It turns out that in a (joincompact) T_0-quasi-metric space there is a dual concept which we shall call a startpoint. With the help of these concepts we are are able to generalize some of the classical results on endpoints in metric spaces to the quasi-metric setting.

Global existence for the stochastic chemotaxis system of Keller-Segel type with multiplicative noise driven by a cylindrical Wiener processes

Z.I. Ali

University of South Africa
alizi@unisa.ac.za/zakaria@aims.ac.za

SAMS Classification: 11, 10, 17, 09 **General Session**

In this work, the study of weak martingale solution to the chemotaxis model of Keller-Segel type subjected to stochastic perturbation is considered on a manifold $\mathcal{M}$ and the problem is supplemented by homogeneous Neumann boundary conditions. Denoting by u the cell density and by v the concentration of the chemical signal, we investigate the coupled stochastic system

$$\begin{cases} d\mathbf{u} &= r_{\mathrm{u}}\Delta\mathbf{u}\,dt - \chi\mathrm{div}\,(V(\mathbf{u},\mathbf{v})\nabla\mathbf{v})dt + F(\mathbf{u})\circ dW_1, \quad x\in\mathcal{M},\ t>0, \\ d\mathbf{v} &= r_{\mathrm{v}}\Delta\mathbf{v}dt + \Theta g(\mathbf{u},\mathbf{v})dt + G(\mathbf{v})\circ dW_2, \quad x\in\mathcal{M}, t>0 \end{cases}$$

where W_1 and W_2 are two independent cylindrical Wiener processes on an a priori unknown filtered probability space $\mathfrak{U}$. Here the terms F and G are nonlinear external forces. The system is supplemented with the initial conditions $\mathbf{u}(0,x)=\mathbf{u}_0(x)$ and $\mathbf{v}(0,x)=\mathbf{v}_0(x)$, $x\in\mathcal{M}$. The positive terms r_{u} and r_{v} are the diffusivity of the cells and chemoattractant, respectively, the positive value χ is the chemotactic sensitivity, Θ a parameter that will be specified later on during the course of the problem. The associated stochastic integrals are interpreted in the Stratonovich sense. We prove the existence of a weak martingale solution to the system under consideration.

References:

[1] Z.I. Ali & E. Hausenblas. Stochastic Keller-Segel model (porous media) perturbed by a time homogeneous spatial Wiener process. Preprint, 2019.

Bounds on Average Eccentricity of Bipartite C_4-free Graphs

A. Alochukwu*

University of Johannesburg, South Africa
aalochukwu@uj.ac.za

P. Dankelmann

University of Johannesburg
pdankelmann@uj.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

Let G be a connected graph of order n. The eccentricity $e_G(v)$ of a vertex v in G is the maximum distance from v to another vertex w in G and the average eccentricity of G, $\mathrm{avec}(G)$, is the arithmetic mean of eccentricities of vertices of G, that is, $\mathrm{avec}(G) = \frac{1}{n}\sum_{v\in V(G)} e_G(v)$. The minimum degree, $\delta(G)$, is the smallest of the degrees of the vertices of G. A graph, G, is said to be C_4-free if it does not contain a 4-cycle as a subgraph and bipartite if and only if it does not contain an odd cycle.

Dankelmann, Goddard and Swart [1] established that for $\delta \geq 2$, the average eccentricity of a connected graph of given order n is at most $\frac{9n}{4(\delta+1)} + \frac{15}{4}$. Dankelmann, Osaye, Mukwembi and Rodrigues [2] strengthened this bound and showed tha it can be improved to $3\lceil\frac{n}{2\delta}\rceil + 5$ for K_3-free graphs and $\frac{15}{4}\lceil\frac{n}{\delta^2-\lceil\delta/2\rceil+1}\rceil + \frac{11}{2}$ for C_4-free graphs.

In this talk, we present these results and show that these bounds can be further improved by a factor of approximately $3/5$ for bipartite C_4-free graphs and this is best possible. We also give asymptotically sharp upper bounds on the average eccentricity of a connected (C_4, C_5)-free graph, of given order and minimum degree.

References:

[1] P. Dankelmann, W. Goddard, H.C. Swart, The average eccentricity of a graph and its subgraphs. *Util. Math.* 65 (2004), 41-51.

[2] P. Dankelmann, F.J. Osaye, S. Mukwembi, B. Rodrigues Upper Bounds on Average Eccentricity of K_3-free and C_4-free graphs *Discrete Math.*

Phase-plane analysis of test particle orbits in regular black holes

M. Amir

Astrophysics and Cosmology Research Unit, School of Mathematics, Statistics and Computer Science, University of KwaZulu-Natal, Private Bag X54001, Durban 4000, South Africa
amirctp12@gmail.com

SAMS Classification: 13 **General Session**

We investigate phase-plane analysis of general relativistic orbits in gravitational field of the Reissner-Nordström type regular black hole spacetime. We employ phase-plane analysis to obtain different phase-plane diagrams of the test particle orbits by varying charge q and dimensionless parameter β, where β contains angular momentum of the test particle. We compute numerical values of radii for the innermost stable orbits and corresponding values of energy required to place the test particle in orbits. Later on, we employ similar analysis on Ayón-Beato-García (ABG) regular black hole and a comparison regarding key results is also included.

References:

[1] B. Dean, *Am. J. Phys.* **67** (1999) 78.
[2] Y. Zhang, J. L. Geng and E. K. Li, *Mod. Phys. Lett. A* **29** (2014) 1450144.
[3] J.P. Hu, Y. Zhang, *Can. J. Phys.* **97** (2019) 58.

Representing spaces of continuous functions as order duals of vector lattices

W. van Amstel

University of Pretoria
sjvdwvanamstel@gmail.com

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Consider the following question: Given a locally compact space L, when is the space of continuous functions that vanish at infinity, $C_0(L)$, a dual space of some Banach space X? Similarly, for a compact space K, one may ask when is the space of continuous functions, $C(K)$, a dual space of some Banach space X? In this talk, we discuss the significance of these questions in the context of C^*-algebras, and pose a similar question in the context of vector lattices: Given a Tychonoff space (completely regular + T_2) Y, when is $C(Y)$ an *order dual* of some vector lattice E? Some preliminary results in this direction will be discussed, along with a review of relevant results from the literature.

Nordhaus-Gaddum inequalities for the number of connected induced subgraphs

E.O.D. Andriantiana*

Rhodes Uuniversity
e.andriantiana@ru.ac.za

A.A.V. Dossou-Olory

University of Johanesburg
audace@aims.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

Hoping to obtain generalisations of results on the number of subtrees, we studied the number $\eta(G)$ of connected induced subgraphs in a graph G. This talk will discuss various Nordhaus-Gaddum inequalities for $\eta(\cdot)$. Characterisations (in some cases only partial) of the graphs that has maximum or minimum $\eta(G) + \eta(\overline{G})$ will be provided for all graphs of a given order, all trees of a given order, among other classes of graph. An effort will also be made to estimate extremal values corresponding to those extremal graphs.

Shedding light on words

M. Archibald* A. Blecher, C. Brennan, A. Knopfmacher

Wits University
{*margaret.archibald, aubrey.blecher, charlotte.brennan, arnold.knopfmacher*}*@wits.ac.za*

T. Mansour

Haifa University, Israel
tmansour@univ.haifa.ac.il

SAMS Classification: 14 **Graph Theory and Combinatorics**

A *word* over an alphabet $[k]$ can be represented by a bargraph, where the height of the i-th column is the size of the i-th part. If North is in the direction of the positive y-axis and East is in the direction of the positive x-axis, a light source projects parallel rays from the North-West direction, at an angle of 45 degrees to the y-axis. These rays strike the cells of the bargraph. We say a cell is lit if the rays strike its West facing edge or North facing edge or both. With the use of matrix algebra we find the generating function that counts the number of lit cells. From this we find the average number of lit cells in a word of length n.

Laplace Adomian decomposition method and Laplace variational iteration method: tools for solving Laplace equations within local fractional operators

V.M. Ariyan*

Mangosuthu University of Technology, Umlazi, South Africa
vernonariyan@gmail.com

H. Jafari

University of South Africa, UNISA0003, South Africa
jafarh@unisa.ac.za

SAMS Classification: 11, 16

Lie Symmetries and Nonlinear DEs

In this work, we utilize the local fractional Laplace Adomian Decomposition Method (LFLADM) and the local fractional Laplace Variational Iteration Method (LFLVIM) to obtain approximate solutions for Laplace equations (LE) within local fractional derivative operators (LFDOs). The efficiency of the considered methods are illustrated by examples. The results obtained by the LFLADM are compared with the results obtained by the LFLVIM. We demonstrate that the two approaches are very effective and convenient for finding the approximate analytical solutions of PDEs with LFDOs.

Non-commutativity of the exponential spectrum

M. Askes*

University of Johannesburg
maskes@uj.ac.za

R.M. Brits

University of Johannesburg
rbrits@uj.ac.za

F.P. Schulz

University of Johannesburg
francoiss@uj.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

In a Banach algebra it is well known, by Jacobson's lemma, that the spectrum satisfies $\sigma(xy) \cup \{0\} = \sigma(yx) \cup \{0\}$ for each pair of elements x, y. In 1976, Harte defined the exponential spectrum of an element in a Banach algebra (see [1]). A very natural question which arises is whether or not the exponential spectrum satisfies the same cyclic property. However, this problem was only formally stated in a 1992 paper by Murphy, in which he provides large classes of Banach algebras for which the nonzero exponential spectrum is cyclic, and moreover exposes conditions on the elements of a Banach algebra which forces the exponential spectrum to satisfy $\epsilon(xy) \cup \{0\} = \epsilon(yx) \cup \{0\}$. Until very recently, the general case has remained unsolved. In this talk we shall discuss a counter example by Klaja and Ransford [2] which exposes elements x and y in a Banach algebra such that $\epsilon(xy) \cup \{0\} \neq \epsilon(yx) \cup \{0\}$. The counter example is constructed using tools from algebraic topology and exploits the connection between homotopy and the principal component of $C(X, B)$ (the Banach algebra of continuous functions from X into a Banach algebra B). An essential ingredient of the construction is the fact that the higher homotopy group $\pi_4(GL_2(\mathbb{C}))$ is non-trivial.

References:

[1] R. Harte, The exponential spectrum in Banach algebras, *Proc. Amer. Math. Soc.* 58 (1976) 114–118.

[2] H. Klaja, T. Ransford, Non-commutativity of exponential spectrum, *Journal of Functional Analysis* 272 (2017) 4158–4164.

[3] G.J. Murphy, The index group, the exponential spectrum, and some spectral containment theorems, *Proc. of the Royal Irish Academy*. Section A: Mathematical and Physical Sciences 92A (1992) 229–238.

Quasi-openness with respect to an interior operator

F.S. Assfaw

University of the Western Cape
348197@myuwc.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

By considering an arbitrary category supplied with a proper $(\mathcal{E}, \mathcal{M})$-factorization system for morphisms we study a concept of codense subobjects with respect to a given categorical interior operator i in the sense of [1]. We then introduce and investigate a notion of quasi-open morphisms with respect to i. Notably, we obtain a characterization of quasi i-open morphisms in terms of i-codense subobjects. Furthermore, we prove that these morphisms are a generalization of the i-open morphisms that were studied in [2]. Examples in topology and algebra are provided.

References:

[1] S.J.R. Vorster. Interior operators in general categories. *Quaest. Math.*, 23(4):405-416, 2000.

[2] G. Castellini. Interior operators, open morphisms and the preservation property. *Appl. Categ. Structures.*, 23(3):311-322, 2015.

Domination versus independent domination in graphs of small regularity

A.A.I. Babikir*

University of Johannesburg
babikirammar@gmail.com

M.A. Henning

University of Johannesburg
mahenning@uj.ac.za

SAMS Classification: 14

Graph Theory and Combinatorics

A set S of vertices in a graph G is a dominating set if every vertex not in S is adjacent to a vertex in S. If, in addition, S is an independent set, then S is an independent dominating set. The domination number $\gamma(G)$ of G is the minimum cardinality of a dominating set in G, while the independent domination number $i(G)$ of G is the minimum cardinality of an independent dominating set in G. It is known [Annals Combin. 16 (2012), 719-732] that if G is a connected 3-regular graph, then $i(G)/\gamma(G) \leq 3/2$, with equality if and only if $G = K_{3,3}$. In this paper, we extend this result to graphs of larger regularity and show that if $k \in \{4, 5, 6\}$ and G is a connected k-regular graph, then $i(G)/\gamma(G) \leq k/2$, with equality if and only if $G = K_{k,k}$.

Coproducts of locally connected frames

D. Baboolal

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

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

It is known that coproducts of connected frames may not be connected. However, locally connected frames behave well with respect to coproducts. We show that the coproduct of a collection of frames is locally connected if and only if each frame is locally connected and all but finitely many of the frames are connected.

References:

[1] I. Kříž and A. Pultr, Products of locally connected locales, *Rendiconti del Circolo Matematico di Palermo*, Serie II, Supplemento No. 11 (1985), 61-70.

[2] J. Picado and A. Pultr, Frames and Locales, Birkhäuser (2012).

[3] L. Yongming, Weak locale quotient morphisms and locally connected frames, *J. Pure and Appl. Alg.* 110(1996), 101-107.

r-Fredholm theory in ordered Banach algebras

R. Benjamin*

Stellenbosch University
ronalda@sun.ac.za

S. Mouton

Stellenbosch University
smo@sun.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Motivated by work done in [1], the central problem being investigated in [2] is that of providing conditions under which the spectral radius of a positive ordered Banach algebra element a lies outside the upper Browder spectrum of a given that it is not an element of its Fredholm spectrum. A positive element satisfying this property is said to have the *upper Browder spectrum property*.

In [3], which displays the development of r-Fredholm theory in general Banach algebras, the concepts of r-invertible, r-Browder, contractive r-Browder and r-Fredholm elements were introduced and studied and the implication

"almost r-invertible r-Fredholm" $\Rightarrow$ "contractive r-Browder"

was established.

In this talk we will introduce the concepts of "*upper r-Browder*" and "*contractive upper r-Browder*" in an ordered Banach algebra [4] and give conditions under which the positive almost r-invertible r-Fredholm elements will be contractive upper r-Browder. The latter led to the recovering (and strengthening) of the results in [2] regarding the upper Browder spectrum property.

References:

[1] E. A. Alekhno: Some properties of essential spectra of a positive operator. *Positivity* 11 (2007), 375 – 386.

[2] R. Benjamin and S. Mouton: The upper Browder spectrum property. *Positivity* 21 (2017), 575 – 592.

[3] R. Benjamin, N.Laustsen and S. Mouton: r-Fredholm theory in Banach algebras. *Glasgow Math. J.* 61 (2019), 615 – 627.

[4] R. Benjamin and S. Mouton: r-Fredholm theory in ordered Banach algebras. *Positivity* (2019), DOI: https://doi.org/10.1007/s11117-019-00683-3

An axiomatic approach to ordinal numbers

I. van der Berg*

University of Stellenbosch
ineke.vdb@gmail.com

Z. Janelidze

University of Stellenbosch
zurab@sun.ac.za

SAMS Classification: 01

Categories, Algebra, Topology, and Logic

There is an order in the world of infinite sets that resembles the order of the natural numbers, given by the ordinal numbers. The order in the former case comes out of the notion of a successor $n+1$ of a natural number n. For ordinals, there are two types of succession: a discrete one which extends the notion of a successor of a natural number, and a continuous one, given by "limit ordinals". In this work we present a new approach to ordinal numbers which results from unification of these two types of succession. This new approach leads to a notion of an *abstract ordinal system*, for which we establish a universal property analogous to the well-known universal property of the natural number system.

Gravitational wave propagation through a medium using the Bondi-Sachs formalism

N.T. Bishop

Rhodes University
n.bishop@ru.ac.za

SAMS Classification: 13

General Session

Gravitational waves (GWs) propagate over large distances in a medium whose properties (the dark matter) are largely unknown. Depending on the physical properties of the dark matter, the GWs may experience changes such as dispersion, phase shift and attenuation. The approach adopted here is that the coefficients in the equations of state of the matter are arbitrary. We wish to determine formulas for any deviation from vacuum propagation.

This problem has received attention in previous works. Here, we use the Bondi-Sachs formalism, which has given additional insights in other cases. We construct exact solutions to the linearized Einstein equations. We are able to do so not for the general case, but when the background density is spherically symmetric with specific functional forms for the radial dependence. However, that is sufficient to be able to obtain expressions for the effect of a thin shell, and then a general density distribution can be modelled by integration over a sequence of thin shells. As a first step, we have determined the effect on GW propagation due to dust.

Some special ideals of pointfree function rings

S. Blose

bloses@unisa.ac.za
UNISA

SAMS Classification: 02, 05 **Categories, Algebra, Topology, and Logic**

Let $\mathcal{R}L$ denote the ring of real-valued continuous functions on a completely regular frame L. In the talk (based on a chapter consisting of new results in my masters dissertation), I will give a natural extension of the **M**-ideals and **O**-ideals of $\mathcal{R}L$ that were introduced in [1]. Whereas the author in that article indexed his ideals with elements of βL, the Stone-Čech compactification of L, my ideals will be indexed by pairs (h, a), where h is a frame homomorphism out of βL into an arbitrary frame K, and a is an element of K. I will present results that relate these new ideals to their antecedents. I will also give an example to show that indexing the way I have done creates new ideals that are not among the **O**-ideals of [1].

References:

[1] T. Dube, Some ring-theoretic properties of almost P-frames, *Algebra Universalis* **60** (2009), 145–162.

Embedding Topological Near-rings

G.L. Booth

Department of Mathematics and Applied Mathematics, Nelson Mandela University, Summerstrand Campus (South), Port Elizabeth, 6031
Geoffrey.Booth@mandela.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

It is well known that an arbitrary ring can be embedded in a ring $\mathrm{End}(G)$ of endomorphisms of an abelian group. Similarly, it has been shown that an arbitrary near-ring can be embedded in a near-ring of self-maps of an additive (but not necessarily abelian) group. In this talk, we will consider what happens when we topologise this problem. Given an arbitrary topological near-ring R, it it possible to embed it in a near ring $N(G)$ of continuous functions of a topological group G? It seems that there is more to this problem than initially meets the eye. What is the most appropriate topology on $N(G)$? Will the embedding be homeomorphic, or just continuous or just open? We will explore some of these intriguing questions.

The localization game on Cartesian products

J Boshoff*

Stellenbosch University
jboshoff@sun.ac.za

A Roux

Stellenbosch University
rianaroux@sun.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

The *localization game* is a variant of the game of Cops and Robbers and was independently introduced in 2018 by Bosek et al. [1] and by Haslegrave et al. [2]. Let $G = (V, E)$ be a simple, connected, undirected graph and let $k > 0$ be a fixed integer. Two players are involved in this game: a Cop who has a team of k cops, and a Robber. To start the game, the Robber chooses a vertex $r \in V$, unknown to the Cop. At the start of each turn, the Cop probes k vertices $B = \{b_1, b_2, \ldots, b_k\}$ and in return receives the vector $\vec{D}(\{r\}, B) = [d_1, d_2, \ldots, d_k]$ where $d_i = d_G(r, b_i)$ for $i = 1, 2, \ldots, k$. If the Cop can determine the exact location of r from $\vec{D}(\{r\}, B)$, the Robber is located and the Cop wins. Otherwise, the Robber is allowed to move to any adjacent vertex and the Cop again probes any k vertices. The game continues in this fashion, where the Cop wins if the Robber can be located in a finite number of turns. The *localization number* $\zeta(G)$, is defined as the smallest k for which the Cop always has a winning strategy. In this talk we investigate the localization number of the Cartesian product of graphs G and H, with a closer look at the case when H is a cycle.

References:

[1] B. Bosek, P. Gordinowicz, J. Grytczuk, N. Nisse, J. Sokó, and M. Sleszynska-Nowak. Localization game on geometric and planar graphs. *Discrete Applied Mathematics*, 251:30-39, 2018.

[2] J. Haslegrave, R. A. Johnson, and S. Koch. Locating a robber with multiple probes. *Discrete Mathematics*, 341(1):184–193, 2018.

Characterization of left coextensive varieties of universal algebras

D. N. Broodryk

University of Cape Town
dbroodryk1@gmail.com

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

An extensive category can be defined as a category $\mathcal{C}$ with finite coproducts such that for each pair X, Y of objects in $\mathcal{C}$, the canonical functor $+ : \mathcal{C}/X \times \mathcal{C}/Y \to \mathcal{C}/(X + Y)$ is an equivalence [1]. We say that a category $\mathcal{C}$ with finite products is left coextensive if the dual canonical functor $\times : X/\mathcal{C} \times Y/\mathcal{C} \to (X \times Y)/\mathcal{C}$ is fully faithful. In order to determine which varieties of universal algebras satisfy this property, we give a syntactical characterization of left coextensive varieties of universal algebras. This is to say that we translate this categorical condition into an equivalent condition regarding the operations and identities of the variety.

References:

[1] A. Carboni, S. Lack, and R. F. C. Walters, Introduction to extensive and distributive categories, *Journal of Pure and Applied Algebra*, 84(2), 1993, 145-158.

Category of graded rings (without 1) is semi-abelian

S.T.K Chili

University of Cape Town
chlsim005@myuct.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

Given a semigroup S, one defines an S-graded ring (without 1) as a family $A = (A_s)_{s\in S}$ of abelian groups equipped with for each $s, s' \in S$ associative partial multiplications $\phi_{s,s'} : A_s \times A_{s'} \to A_{ss'}$. In this talk, we give a presentation of such a structure as a variety of universal algebras (i.e a set A together with operations satisfying certain identities) and show that (the) category of S-graded rings (without 1) is a semi-abelian variety of universal algebras. After this, we discuss a few results about S-graded rings.

P-adic Numbers: An Overview

A.A. de Clercq

University of Pretoria
adriaandeclercq1998@gmail.com

SAMS Classification: 03 **General Session**

The p-adic numbers is a number system that turns our intuition on sequences and convergence on its head. Their development stems from a question as old as number theory itself: the question of the solvability of Diophantine equations. These ancient equations are notoriously difficult to solve and today remain a rich area of study. The p-adic numbers come in as a way of applying the powers of analysis to a problem that, at first glance, seems entirely algebraic. In this talk, I will give an overview of p-adic numbers. I will describe what they are and how they are used in application to some powerful ideas in number theory.

Unbounded convergence structures

J.J. Conradie*

University of Cape Town
jurie.conradie@uct.ac.za

J.H. van der Walt

University of Pretoria
janharm.vanderwalt@up.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Although order convergence is an important and useful notion of convergence in vector lattices (Riesz spaces), it does not coincide with almost everywhere convergence in, for example, the L_p spaces. To give an order-theoretic description of almost everywhere convergence in these spaces, a modification of order convergence known as unbounded order convergence is necessary. This notion has been extensively investigated in recent years, and has lead to introduction of the related idea of unbounded versions of locally solid topologies on Riesz spaces.

It is known that in general order convergence in a Riesz space is not topological, but it can be thought of as a vector space convergence structure, and the same is true for unbounded order convergence. In this talk we look at the possibility of "unbounding" a locally solid convergence structure on a Riesz space, and illustrate the process with examples.

Goldblatt-Thomason for LE-logics

W. Conradie*

University of the Witwatersrand
willem.conradie@wits.ac.za

A. Palmigiano

Vrije Universiteit Amsterdam
palmigiano.appliedlogictudelft@gmail.com

A. Tzimoulis

Vrije Universiteit Amsterdam
apostolos@tzimoulis.eu

SAMS Classification: 01 **Categories, Algebra, Topology, and Logic**

The Goldblatt-Thomason theorem characterizes those elementary classes of Kripke frames which are definable by modal formulas as exactly those that are closed under disjoint unions, generated subframes, bounded morphic images and reflect ultrafilter extensions. It can be seen as a relational dual of Birkhoff's variety theorem for Boolean aglebras with operators. In this talk we will briefly review this classical theorem before proposing and proving a uniform generalization for logics algebraically captured by normal lattice expansions (normal LE-logics).

Free algebras for varieties of bilattices via duality theory

A. Craig*

University of Johannesburg
acraig@uj.ac.za

B.A. Davey

La Trobe University, Melbourne, Australia
b.davey@latrobe.edu.au

M. Haviar

Matej Bel University, Banská Bystrica, Slovakia
miroslav.haviar@umb.sk

SAMS Classification: 01, 02 **Categories, Algebra, Topology, and Logic**

Natural duality theory [2] provides a method for obtaining topological dualities for finitely generated varieties and quasivarieties of algebras. When such algebras have a distributive lattice reduct, it is also possible to consider a restricted Priestley duality for the class of algebras. The dual spaces of the algebras are then Priestley spaces with additional structure. We use a result from [1] that shows how to obtain the underlying poset of the restricted Priestley dual of such a distributive lattice-based algebra. Combining that technique with a natural duality for varieties of bilattices [3], we demonstrate how to calculate the size of free algebras in these varieties of bilattices.

References:

[1] Cabrer, L.M., Priestley, H.A.: Coproducts of distributive lattice-based algebras. *Algebra Universalis* 72, 251–286 (2014)

[2] Clark, D.M., Davey, B.A.: Natural Dualities for the Working Algebraist. Cambridge University Press, Cambridge (1998)

[3] Craig, A.P.K., Davey, B.A., Haviar, M.: Expanding Belnap: dualities for a new class of default bilattices. Submitted: https://arxiv.org/abs/1808.09636

Size of Graphs and Digraphs with given Diameter and Connectivity Constraints

P. Dankelmann

University of Johannesburg
pdankelmann@uj.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

Let G be a connected graph. The edge-connectivity of G is defined as the smallest number of edges whose removal renders G disconnected. The diameter of G is the largest of the distances between two vertices of G. In this talk we first determine the maximum size of a graph of given order, diameter, and edge-connectivity λ, where $2 \leq \lambda \leq 7$, thus completes the determination of the maximum size of graphs of given order, diameter, and edge-connectivity, which was begun in the 1980s. We then generalise our result to a large class of digraphs, Eulerian digraphs, which contains all graphs. We present a general framework which shows that several similar upper bounds on the size of graphs of given diameter can be generalised to Eulerian digraphs.

Dynamics of topological solitons in resonantly driven damped ϕ^4 equation.

A. Dika*

Department of Mathematics, UCT
DKXALA002@myuct.ac.za

I. Barashenkov

Department of Mathematics, UCT
igor.barashenkov@uct.ac.za

SAMS Classification: 11 **General Session**

This study aims to elucidate the dynamics of the wobbling kink, direct and parametric driving at a range of resonance frequencies to any order in the amplitude of the wobbling mode. We include the collective variable $\kappa(t)$ in a set of asymptotic expansions pioneered by Barashenkov and Oxtoby with the objective to capture quasisecular terms at each order of the expansion. In each case, we derive amplitude equations which describe the evolution of the amplitude of the wobbler as well as the kinks velocity. These equations predict multi-stability and hysteretic transitions in the wobbling amplitude for each driving frequency. We show that, for the direct driving, the strongest resonance is at half the natural frequency, but there is also a weaker resonance when the driving frequency equals the natural wobbling frequency itself. For the parametric resonance, the strongest occurs when the driving frequency equals the natural wobbling frequency and not at the double of that value. We also show that this resonance is accompanied by the translational motion of the kink which agrees with the former studies.

A collective variable approach for dispersion managed dual-core fiber lasers with third-order dispersion

R.B. Djob*

rogerdjob@yahoo.fr

A. Govindarajan

govin.nld@gmail.com

SAMS Classification: 11,17 **General Session**

It is known that after a particular distance of evolution in fiber lasers, two (input) asymmetric soliton like pulses emerge as two (output) symmetric pulses having same and constant energy. We report such a compensation technique in dispersion managed fiber lasers by means of a semi-analytical method known as collective variable approach (CVA) with including third-order dispersion (TOD). The minimum length of fiber laser, at which the output symmetric pulses are obtained from the input asymmetric ones, is calculated for each and every pulse parameters numerically by employing Runge-Kutta method. The impacts of intercore linear coupling, asymmetric nature of initial parameters and TOD on the evolution of pulse parameters and on the minimum length are also investigated. It is found that strong intercore linear coupling parameter and asymmetric nature of input pulse parameters result in the minimum length. Also, the role of TOD tends to increase the width of the pulses as well as their energies. Besides, chaotic patterns and bifurcation points on the minimum length of the fiber owing to the impact of TOD are also reported in a nutshell.

Application of bivariate-spectral quasilinearization method to second grade fluids

S.G. Dlongolo

University of KwaZulu-Natal
simgloria24@gmail.com

SAMS Classification: 11 **General Session**

In this talk, heat and the mass transfer from an electrically conducting second grade magnetohydrodynamic fluid flow over a stretching sheet is investigated. Second-grade fluids are non-Newtonian fluids that possess both elastic and viscous properties. It is one of the simplest subclasses of differential type fluids for which an exact solution may be obtained. The partial differential equations that describe the flow are solved numerically using the bivariate spectral quasilinearization method. The findings on various flow characteristics are presented and analyzed. The accuracy of the method is determined using a residual error analysis. We show among other results that the fluid velocity in the boundary layer region increases with the second grade fluid parameter and decreases with an increase in the porous parameter, chemical reaction parameter and the magnetic field parameter.

Cut vertex and the maximum number of connected induced subgraphs

A.A.V. Dossou-Olory

Department of Mathematics and Applied Mathematics, University of Johannesburg
audace@aims.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

Let n, c be positive integers such that $c \leq n-2$. Denote by $\mathcal{G}(n;c)$ the n-vetex graph obtained from a clique of order $n-c$, and $n-c$ disjoint paths of order $\lfloor \frac{n}{n-c} \rfloor$ and $\lceil \frac{n}{n-c} \rceil$ by identifying bijectively every vertex of the clique with one leaf of one of the paths. The graph $\mathcal{G}(n;c)$ was recently shown to minimise the Wiener index among connected graphs with order n and c cut vertices. We prove that the same type of graph also maximises the number of connected induced subgraphs, and $\mathcal{G}(n;c)$ is unique with this property.

Amenable and locally amenable algebraic frames

T. Dube

University of South Africa (UNISA)
dubeta@unisa.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

Call a prime element of an algebraic frame L *amenable* if it comparable to every compact element. Say L is an *amenable frame* if all its primes are amenable. If the localization of L at every prime element is amenable, say L is *locally amenable*. These concepts are motivated by notions of divided and locally divided commutative rings. In the talk I will show that L is (i) amenable precisely when its prime elements form a chain, and (ii) locally amenable precisely when its prime elements form a tree. Given any prime element p of L, I will construct a certain pullback in the category of algebraic frames with the finite intersection property on compact elements, and characterize (in terms of the localization L_p and the quotient $\uparrow p$ of L) when this pullback is amenable and when it is locally amenable.

Positivity of dual maps for fermionic systems

R. Duvenhage*

UP
rocco.duvenhage@up.ac.za

V. Crismale

Bari
vitonofrio.crismale@uniba.it

F. Fidaleo

Rome
fidaleo@axp.mat.uniroma2.it

SAMS Classification: 09 **Functional Analysis and Operator Theory**

In order to formulate a form of detailed balance tailored to fermionic systems, one has to be able to define certain duals (or adjoints) of dynamical maps, and confirm that they have the required positivity properties. This talk will treat some of the mathematical background to this problem, and then outline the solution.

Distance domination and generalized eccentricity in graphs with given minimum degree

P. Dankelmann

Department of Mathematics, University of Johannesburg
pdankelmann@uj.ac.za

D.J. Erwin*

Laboratory for Discrete Mathematics and Theoretical Computer Science, Department of Mathematics and Applied Mathematics, University of Cape Town
david.erwin@uct.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

Let G be a connected graph and $k \in \mathbb{N}$. The k-distance domination number of G is the smallest cardinality of a set S of vertices such that every vertex of G is within distance k from some vertex of S. While for $k = 1$, i.e., for the ordinary domination number, the problem of finding asymptotically sharp upper bounds in terms of order and minimum degree of the graph has been solved, corresponding bounds for $k > 1$ have remained elusive. In this talk we present an asymptotically sharp upper bound on the k-distance domination number of a graph in terms of its order and minimum degree, which significantly improves on bounds in the literature. We also obtain an asymptotically sharp upper bound on the p-radius of graphs in terms of order and minimum degree. For $p \in \mathbb{N}$, the p-radius of G is defined as the smallest integer d such that there exists a set S of p vertices of G having the property that every vertex of G is within distance d of some vertex in S. We also present improved bounds for graphs of given order, minimum degree and maximum degree, for triangle-free graphs and for graphs not containing a 4-cycle as a subgraph.

Stochastic Integral and the Existence of Quadratic Variation for Càdlàg Price Paths

L.C. Galane*

University of Limpopo
lesiba.galane@ul.ac.za

F.J. Mhlanga

University of Limpopo
farai.mhlanga@ul.ac.za

R.M. Lochowski

Warsaw School of Economics
rlocho314@gmail.com

SAMS Classification: 17 **General Session**

In this talk we present the classical stochastic integral for càdlàg processes. In addition, we prove the existence of quadratic variation for càdlàg finite variation processes. This result will also be shown in the trendiest mathematical settings called Model-Free. In particular, using the pathwise version of the Burkholder-Davis-Gundy inequality, it became possible to define the a stochastic integral for càdlàg price paths with mildly restricted downward size of jumps.

References:

[1] Olav Kallenberg, Probability and its Applications, 2nd ed., Springer-Verlag, Berlin, 2002

[2] Daniel Revuz and Marc Yor, Continuous Martingales and Brownian Motion, 3^{rd} ed., 293 of Grundlehren der Mathematischen Wissenschaften, Springer-Verlag, Berlin, 2005

[3] L.C.G. Rogers and David Williams, Diffussions, Markov Processes, and Martingales, 2^{nd} ed., Cambrigde University Press, 2000

[4] Vladimir Vovk and Glenn Shafer, Game-Theoretic Probability and Finance: It's only a Game!, 1^{st} ed., Wiley Series, 2018

[5] Vovk, V, Continuous-time Trading and the Emergence of Probability, *Finance and Stochastic*, 16, 4, 561–609, 2012

[6] Vovk, V, Itô Calculus Without Probability in Idealized Financial Markets, *Lithuanian Mathematical Journal*, 55, 2, 270–290, 2015

Bifiltrations of double complexes

A. Goswami

University of Johannesburg
agoswami@uj.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

In this talk we will describe bifiltrations associated with a double complex. We also use them to construct a spectral sequence for the horizontal and vertical homologies of the double complex.

Categorical algebraic properties of the category with objects frames and morphisms binary meet and arbitrary join preserving maps

J.R.A Gray

Stellenbosch University
jamesgray@sun.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

A frame can be thought of as a poset with arbitrary joins and binary meets distributing over arbitrary joins. With this (albeit unnatural from the point of view of topology) perspective the natural morphisms are those maps which preserve arbitrary joins and binary meets. Frames together with these morphism form a pointed category which contains the usual category of frames as a non-full sub-category (such that the inclusion has a left adjoint). The aim of this talk is to explain that this enlarged category of frames has the following categorical algebraic properties: it has generic split extensions, normalizers, and centralizers. Time permitting we will also discuss some connections between this enlarged category of frames and the comma category of the category of frames over the two element frame.

Convergence of new discontinuous Galerkin methods for near-incompressible and near-inextensible transversely isotropic materials

B.J. Grieshaber*

University of Cape Town
beverley.grieshaber@uct.ac.za

F. Rasolofoson

University of Cape Town
rslfar002@myuct.ac.za

B.D. Reddy

University of Cape Town
daya.reddy@uct.ac.za

SAMS Classification: 16

General Session

Finite elements methods (FEM) are a well-established approach to solving boundary value problems (BVPs) approximately. Discontinuous Galerkin (DG) methods are a variant of FEM that have been used for circumventing problems that arise due to very small parameter values, when the standard method may perform poorly. In the context of solid mechanics, examples of such problems are volumetric and extensional locking on respectively near-incompressible and near-inextensible materials. We present new DG methods for solving BVPs on transversely isotropic linear elastic materials, and show by a theoretical analysis that they converge uniformly with respect to compressibility and extensibility. Supporting numerical results illustrate that the new methods overcome locking, yielding very good approximations.

A Ricci-type Flow on Globally Null Manifolds and Its Gradient Estimates

M.H. Hamed*

University of KwaZulu-Natal, Sch. of Maths., Stats and Comp. Sci.
wdhamed82@gmail.com

F. Massamba

University of KwaZulu-Natal, Sch. of Maths., Stats and Comp. Sci.
Massamba@ukzn.ac.za

SAMS Classification: 04 **Categories, Algebra, Topology, and Logic**

Locally, a screen integrable globally null manifold M splits through a Riemannian leaf M' of its screen distribution and a null curve $\mathcal{C}$ tangent to its radical distribution. The leaf M' carries a lot of geometric information about M and, in fact, forms a basis for the study of expanding and non-expanding horizons in black hole theory. In the present paper, we introduce a Ricci-type flow in M' via the intrinsic Ricci tensor of M. Several new gradient estimates regarding the flow are proved.

Towards partial derivations of rings

Y Hardy*

University of the Witwatersrand
yorick.hardy@wits.ac.za

A. Fošner

University of Primorska
ajda.fosner@fm-kp.si

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

We study derivations of rings R which have the form $d(x) = (ad_1)(x) + (bd_2)(x)$, where d_1 and d_2 are derivations of subrings of R and a and b are endomorphisms of the underlying additive group. If such a d exists for a given d_1 and d_2 and corresponding subrings, then d_1 and d_2 are called partial derivations of the ring. The ring $R[x_1, \ldots, x_n]$ of polynomials in $x_1, \ldots, x_n$ with coefficients in the unital ring R has partial derivations $\partial/\partial x_j$. In [1, Theorem 1.2.1], Nowicki showed that every derivation of $R[x_1, \ldots, x_n]$ can be expressed in the left-module generated by the derivations $\partial/\partial x_j$. Chu et. al. define a partial derivation on a product of normed algebras as follows [2]. Let $d_j : \mathcal{A}_1 \times \cdots \times \mathcal{A}_n \to \mathcal{B}$ be a map which is linear in $\mathcal{A}_j$ and $\mathcal{B}$ is a Banach algebra. Then d_j is a (j-th) partial derivation if there exists $f_j : \mathcal{A}_j \to \mathcal{B}$ such that

$$d_j(\ldots, x_j y_j, \ldots) = f_j(x_j) d_j(\ldots, y_j, \ldots) + d_j(\ldots, x_j, \ldots) f_j(y_j).$$

Our notion of a partial derivation of a direct product ring follows a slightly different approach to Chu et. al., but provides that every derivation has the form $d(x) = (ad_1)(x) + (bd_2)(x)$. We give additional examples of partial derivations and some initial results towards a generalization of [1, Theorem 1.2.1].

References:

[1] Andrzej Nowicki. Polynomial derivations and their rings of constants. Uniwersytet Mikołaja Kopernika, Toruń, 1994.

[2] Hahng-Yun Chu, Se-Hyun Ku, and Jong-Suh Park.k Partial stabilities and partial derivations of n-variable functions. *Nonlinear Analysis: Theory, Methods & Applications*, 72(3):1531–1541, 2010.

The product of the total restrained domination numbers of a graph and its complement

J.H. Hattingh*

Department of Mathematics, East Carolina Univerity, Greenville NC 27858 USA
hattinghj@ecu.edu

E.J. Joubert

Department of Mathematics, University of Johannesburg, Auckland Park, 2006 South Africa
ejoubert@uj.ac.za

SAMS Classification: 14

Graph Theory and Combinatorics

Let $G = (V, E)$ be a graph. A set $S \subseteq V$ is a total restrained dominating set if every vertex is adjacent to a vertex in S, and every vertex in $V - S$ is adjacent to a vertex in $V - S$. The total restrained domination number of G, denoted $\gamma_{tr}(G)$, is the smallest cardinality of a total restrained dominating set of G. In this paper we show that if G is a graph of order $n \geq 4$, then $\gamma_{tr}(G)\gamma_{tr}(\overline{G}) \leq 4n$. We also characterize the graphs achieving the upper bound.

Transversals in Uniform Linear Hypergraphs

M.A. Henning*

University of Johannesburg
mahenning@uj.ac.za

A. Yeo

University of Southern Denmark
yeo@imada.sdu.dk

SAMS Classification: 14 **Graph Theory and Combinatorics**

The transversal number $\tau(H)$ of a hypergraph H is the minimum number of vertices that intersect every edge of H. A k-uniform hypergraph has all edges of size k. Let $\mathcal{L}_k$ denote the class of k-uniform linear hypergraphs, where in a linear hypergraph every two distinct edges intersect in at most one vertex. We consider the problem of determining the best possible constants q_k (which depends only on k) such that $\tau(H) \leq q_k(n_H + m_H)$ for all $H \in \mathcal{L}_k$, where $n_H = |V(H)|$ and size $m_H = |E(H)|$. It is known that $q_2 = \frac{1}{3}$ and $q_3 = \frac{1}{4}$. We show that $q_4 = \frac{1}{5}$, implying that the bound on the transversal number for linear hypergraphs is better than for non-linear hypergraphs in the case of 4-uniformity. Using the affine plane $AG(2,4)$ of order 4, we show there are a large number of densities of hypergraphs $H \in \mathcal{L}_4$ such that $\tau(H) = \frac{1}{5}(n_H + m_H)$. Key to our proof is the new technique of the deficiency of a hypergraph we introduce. We show that the asymptotic behaviour of q_k as k grows is of the order $\ln(k)/k$.

Two-phase Flow: Hyperbolicity and Analytical Solution

R. S. Herbst*

University of Johannesburg
sherbst@uj.ac.za

SAMS Classification: 07,11

Lie Symmetries and Nonlinear DEs

In this current work we examine the hyperbolic structure of the mixture formulation two-phase flow equations and provide some approaches to analytical solutions. We provide the analytical solutions to the eigenvalues as a means of illustrating the domain of hyperbolicity and thus the limitations of the current model. This is dependent on the equation of state which varies according to application. Lastly, we provide some analytical solutions for a set of Riemann problems related to shock waves and rarefaction fans. These are compared with numerical solutions.

References:

[1] Zeidan, D., and Arezki Slaouti. Validation of hyperbolic model for two-phase flow in conservative form. *International journal of computational fluid dynamics* 23.9 (2009): 623-641.

[2] Romenski, E., et al. Hyperbolic conservative model for compressible two-phase flow. Reprint of the Isaac Newton Institute for Mathematical Sciences, NI03022-NPA, Cambridge, UK (2003): 1-13.

[3] Zeidan, D. The Riemann problem for a hyperbolic model of two-phase flow in conservative form. *International Journal of Computational Fluid Dynamics* 25.6 (2011): 299-318.

[4] Zeidan, D., and H. D. Ng. Computational methods for gas dynamics and compressible multiphase flows. *Shock Waves* (2019): 1-2.

Chaotic Dynamics in the Peyrard-Bishop-Dauxois Model of DNA

M. Hillebrand*

Department of Mathematics and Applied Mathematics, University of Cape Town, South Africa
malcolm.hillebrand@gmail.com

G. Kalosakas

Department of Materials Science, University of Patras, Greece
georgek@upatras.gr

Ch. Skokos

Department of Mathematics and Applied Mathematics, University of Cape Town, South Africa
haris.skokos@uct.ac.za

SAMS Classification: 12 **General Session**

The Peyrard-Bishop-Dauxois (PBD) model of DNA [1], models DNA molecules as one dimensional lattices of adenine-thymine (AT) and guanine-cytosine (GC) base pairs. It has been shown to accurately reproduce several biological results through a relatively simple nonlinear potential. We use symplectic integration techniques [2] to numerically simulate the time evolution of DNA molecules and study their dynamical properties. In particular, we study the chaoticity of DNA sequences, quantified through the most common chaos indicator, the maximum Lyapunov Exponent (mLE) (see [3] and references therein). We investigate the effects of heterogeneity and disorder on the mLE [4], studying the effects of I) the composition of sequences in terms of AT and GC base pairs, and II) the ordering of the base pairs – comparing grouped and evenly dispersed base pairs, quantified using the alternation index [5]. We present the mLE computed at a range of temperatures, from well below physiological temperatures up to denaturation points, showing the effects of heterogeneity on the dynamics of DNA across this spectrum.

References:

[1] Dauxois, T., Peyrard, M., Bishop, A. R., Entropy-driven DNA denaturation, *Phys. Rev. E*, **47**, R44 (1993).

[2] Blanes, S., Moan. P., Practical symplectic partitioned Runge-Kutta and Runge-Kutta-Nyström methods, *Journ. Comp. App. Math.*, **142**, 313 (2002).

[3] Skokos, Ch., The Lyapunov Characteristic Exponents and Their Computation, *Lect. Notes Phys.*, **790**, 63 (2010).

[4] Hillebrand, M., Schwellnus, A., Kalosakas, G., Skokos, Ch., Heterogeneity and chaos in the Peyrard-Bishop-Dauxois DNA model, *Phys. Rev. E*, **99**, 022213 (2019).

[5] Hillebrand, M., Paterson-Jones, G., Kalosakas, G., Skokos, Ch., Distribution of Base Pairs Alternations in a Periodic DNA Chain: Application of Pólya Counting to a Physical System, *Regul. Chaot. Dyn.*, **23**, 135 (2018).

Coextensivity and the strict refinement property

M.A. Hoefnagel

University of Stellenbosch
mhoefnagel@sun.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

In universal algebra, various refinement properties exist for direct-product decompositions, all of which give information about the uniqueness of such decompositions. One of the strongest of these properties, the *strict refinement property*, implies that any isomorphism between a product of irreducible structures is uniquely determined by a family of isomorphisms between the factors. Examples of structures which have strict refinements are any lattice, implication algebra, or more generally any congruence distributive algebra, as well as any unitary ring, centerless/perfect group, or any connected poset/graph. Almost all geometric structures possess the dual property, which is mainly due to the fact that almost all categories of geometric structures are extensive. In this talk we present an analysis of the relationship between the strict refinement property and extensivity. In particular, we introduce the notion of an $\mathcal{M}$-coextensive object, which highlights this connection. When $\mathcal{M}$ is the class of all product projections in a category, then $\mathcal{M}$-coextensive objects are called *projection-coextensive*. This notion is closely related to *Boolean categories* in the sense of E. Manes: every object in a co-Boolean category is projection-coextensive. We show that in a category with finite products, the poset of product projections of a projection-coextensive object is a Boolean lattice, and moreover we show how this is characteristic of projection-coextensivity. This result is similar to a result for objects in a Boolean category, and can be seen as a generalization one of the main characterizations of the strict refinement property.

Unbounded Toeplitz operators with rational symbols having poles on the unit circle

G.J. Groenewald

North West University
Gilbert.Groenewald@nwu.ac.za

S. ter Horst*

North West University
Sanne.TerHorst@nwu.ac.za

J.J. Jaftha

University of Cape Town
jacob.jaftha@uct.ac.za

A.C.M. Ran

VU Amsterdam/North West University
a.c.m.ran@vu.nl

SAMS Classification: 09 **Functional Analysis and Operator Theory**

In this talk we consider an unbounded Toeplitz-like operator on H^p with a rational symbol that has poles on the unit circle. In case $p = 2$, the symbol is proper and only has poles on the unit circle, such operators appear as adjoint of an unbounded Toeplitz operator studied by Sarason. Since the symbol is rational, it is possible to describe Fredholm properties and various parts of the spectrum explicitly. Also, for $p = 2$ symmetricness and the existence of a selfadjoint extension can be characterized. The talk is based on parts of [1-3].

References:

[1] G.J. Groenewald, S. ter Horst, J. Jaftha and A.C.M. Ran, A Toeplitz-like operator with rational symbol having poles on the unit circle I: Fredholm properties, *Oper. Theory Adv. Appl.* **271** (2018), 239–268.

[2] G.J. Groenewald, S. ter Horst, J. Jaftha, and A.C.M. Ran, A Toeplitz-like operator with rational symbol having poles on the unit circle II: the spectrum, *Oper. Theory Adv. Appl.* **272** (2019), 133–154.

[3] G.J. Groenewald, S. ter Horst, J. Jaftha, and A.C.M. Ran, A Toeplitz-like operator with rational symbol having poles on the unit circle II: the adjoint, *Integr. Equ. Oper. Theory*, to appear.

Topogeneous orders induced by functors

C.B. Iragi

University of the Western Cape
3418199@myuwc.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

Closure and interior operators on an abstract category were introduced in [1,5] respectively some decades ago. Since then, they have been utilised to study many topological notions [3,4]. In the case of closure operators however, it was observed that many natural and useful closure operations cannot be described by means of classical closure operators (depending on one parameter) see [4].

Recently topogeneous orders were introduced [2] and shown to play pivotal roles within this context, the most pleasing being that of unifying closure, interior and neighborhood operators. In particular it was proved that closure and interior operators are special cases of topogeneous orders.

In this talk, we will be considering topogeneous orders induced by special functors. We will prove that the so-called strict morphisms with respect to such topogeneous orders generalise closed morphisms in the sense of [4]. Next we will look at strict morphisms with respect to two topogeneous orders and show that they encompass closed morphisms with respect to two closures operators [3]. We will end the talk with some examples of topogeneous orders induced by functors, in particular fibrations and cofibrations.

References:

[1] D.Dikranjan and E.Giuli Closure operators I. *Topology and its Applications*, 27(2):129–143, 1987.

[2] D. Holgate, M. Iragi, and A. Razafindrakoto. Topogenous and nearness structures on categories. *Appl. Categor. Struct*(24):447–455, 2016.

[3] D. Holgate, A generalisation of the functional approach to compactness. *Topology and its Applications*, 156(12):2101–2108, 2009.

[4] G. Castellini, E.Giuli, Closure operators with respect to a functor. *Applied categorical structures*, 9(5):525–537, 2001.

[5] S. J. R. Vorster. Interior operators in general categories. *Quaest. Math.*, 23(4):405–416, 2000.

A construction of transitive quasi-uniformities compatible with closure (interior) operator in category

M. Iragi

University of the Western Cape

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

The recent observation [3] that for every idempotent interior (closure) operator in a category there is at least a transitive quasi-uniformity [2] which generates it, together with Fletcher's classical construction [1] that all transitive quasi-uniformities of a topological space can be described in terms of interior preserving open covers of the space raise the question whether one can depart from an idempotent interior (closure) operator and find a categorical construction that describes all the transitve quasi-uniformities which generate that interior (closure). The talk will address this question. We obtain a construction that includes all Fletcher's quasi-uniformities when applied to topological spaces and leads to a number of applications in Algebra. We shall also have a closer look at the case of non-idempotent interior (closure) operator.

References:

[1] P. Fletcher, On totally bounded quasi-uniform spaces, *Arch. Math.* 21 (1970), pp. 396–401.

[2] D. Holgate and M. Iragi, Quasi-uniform and syntopogenous structures on categories, *Topology and its Applications*, 263 (2019), pp. 16–25.

[3] D. Holgate and M. Iragi, Quasi-uniform structures determined by closure operators, *Topology and its Applications*, under review (2019).

A numerical method for solving variable order integro-differential equations

H. Jafari*

University of South Africa, UNISA0003, South Africa
jafarh@unisa.ac.za

R.M. Ganji

University of Mazandaran, Babolsar, Iran
r.moallem.ganji@gmail.com

SAMS Classification: 16, 12

General Session

The variable order differential equations (VODEs) denotes a generalization of fractional differential equations (FDEs) which was found as very efficient and interesting tool in different scientific fields [1,2,3].
In this work, we use Taylor, Chebychev and Legendre polynomials to obtain numerical solution of variable order Integro-differential equations (VOIDEs). With the help the basis polynomials and collocation method, the VOIDEs reduce to a system of algebraic equations. Then, we solve the system and obtain the approximate solution. Two examples are given to verify the efficiency of the proposed method.

References:

[1] Y.M. Chen, Y.Q. Wei, D.Y. Liu , H. Yu, Numerical solution for a class of nonlinear variable order fractional differential equations with Legendre wavelets, *Applied Mathematics Letters* 46 (2015) 83–88.

[2] C. F. Lorenzo, T.T. Hartley , Variable order and distributed order fractional operators, *Nonlinear Dynam.* 29 (2002), 57–98.

[3] S.G. Samko , Integration and differentiation to a variable fractional order , *Integral Transform Spec Funct*, 1, (4) (1993) 277–300.

Analysis of a Toeplitz-like operator generated by a rational matrix function having poles on $\mathbb{T}$: matrix case

J.J. Jaftha*

University of Cape Town
jacob.jaftha@uct.ac.za

S. ter Horst

North-West University
Sanne.TerHorst@nwu.ac.za

G.J. Groenewald

North-West University
Gilbert.Groenewald@nwu.ac.za

A.C.M. Ran

Vrije Universiteit, Amsterdam
a.c.m.ran@vu.nl

SAMS Classification: 09 **Functional Analysis and Operator Theory**

This presentation concerns the analysis of a Toeplitz-like operator generated by a rational matrix function having poles on $\mathbb{T}$. It extends the analysis of such operators generated by scalar rational functions with poles on $\mathbb{T}$ found in [1], [2] and [3]. A Wiener-Hopf type factorization of rational matrix functions with poles and zeroes on $\mathbb{T}$ is introduced and then used to analyse the Fredholm properties of Toeplitz-like operators. A formula for the index, based on the factorization, is given. Furthermore, it is shown that the determinant having no zeroes on $\mathbb{T}$ is not sufficient for being Fredholm, which is in contrast to the classical case where the symbol has no poles on $\mathbb{T}$.

References:

[1] G.J. Groenewald, S. ter Horst, J. Jaftha, A.C.M. Ran, A Toeplitz-like operator with rational symbol having poles on the unit circle I: Fredholm properties, *Oper. Theory Adv. Appl.*, Vol. 271 (2018), 239 – 268.

[2] G.J. Groenewald, S. ter Horst, J. Jaftha, A.C.M. Ran, A Toeplitz-like operator with rational symbol having poles on the unit circle II: The adjoint, *Oper. Theory Adv. Appl.*, Vol. 272 (2019), 133 – 154.

[3] G.J. Groenewald, S. ter Horst, J. Jaftha, A.C.M. Ran, A Toeplitz-like operator with rational symbol having poles on the unit circle III: The spectrum, *Integr. Equ. Oper. Theory*, **91** (2019), no. 43, https://doi.org/10.1007/s00020-019-2542-2.

Locally sectionable maps and van Kampen's theorem

R. Brown

Bangor University (UK)
ronnie.profbrown@btinternet.com

G. Janelidze*

University of Cape Town
george.janelidze@uct.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

After a brief survey on van Kampen type theorems and their groupoid versions (cf. [1]), we present a new such theorem that extends the main result of [2] by replacing an open covering family of subsets of the base space B with a locally sectionable continuos map onto B. We conclude with various remarks on related simplicial and categorical constructions. Various technical details we omit can be found in [3].

References:

[1] R. Brown, From groups to groupoids: a brief survey, *Bull. London Math. Soc.* 19 (1987) 113–134.

[2] R. Brown and A. R. Salleh, A van Kampen theorem for unions of non-connected spaces, *Arch. Math.* 42, 1984, 85–88.

[3] R. Brown and G. Janelidze, Open covers, locally sectionable maps, sets of base points, and van Kampen's theorem, arXiv:1910.11620 [math.AT]

Noetherian Form of Sets

Z. Janelidze*

Stellenbosch University
zurab@sun.ac.za

F. K. van Niekerk

Stellenbosch University
16448553@sun.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

The question of finding a self-dual axiomatic setting in which isomorphism theorems and other general theorems for group-like structures can be established, goes back to [3]. There, the focus was on the case of abelian groups. An answer to this question for non-abelian groups is proposed in [2]. In this talk we will show that not only does the category of sets fit in the axiomatic framework of [2], but so does even any variety of universal algebras. The term 'noetherian form' is chosen for such framework, because of the vision of Emmy Noether for abstract algebra, and particularly, for her discovery of the first few isomorphism theorems [4]. The noetherian form that we identify over any variety of universal algebras seems to be convenient for revisiting Emmy Noether's program of 'set-theoretic approach' to the study of algebraic structures. As we will show, this axiomatic framework that brings together subalgebras and congruences under one lattice and it turns out, for instance, that the known isomorphism theorems for universal algebras can be obtained by specializing the theory developed in [2] to this particular case.

See [1,2,5,6] and the references there for other developments around the study of noetherian forms.

References:

[1] A. Goswami, Salamander lemma for non-abelian group-like structures, *Journal of Algebra and Its Applications*, Online Ready, 2019.

[2] A. Goswami and Z. Janelidze, Duality in Non-Abelian Algebra IV. Duality for groups and a universal isomorphism theorem, *Advances in Mathematics* 349 (2019), 781–812.

[3] S. Mac Lane, Duality for groups, *Bull. Am. Math. Soc* 56 (1950), 485–516.

[4] E. Noether, Abstrakter Aufbau der Idealtheorie in algebraischen Zahl- und Funktionenkörpern, *Math. Ann.* 96 (1927), 26–61.

[5] F. K. van Niekerk, Biproducts and commutators for noetherian forms, *Theory and Applications of Categories* 34 (2019), 961–992.

[6] P.-J. van Zyl, Towards Projective Set Theory, MSc Thesis, Stellenbosch University, 2017.

Constant subcategories via dual closure operators.

R.S. Jansen

University of the Free State
jansenrs@ufs.ac.za

SAMS Classification: 01

Categories, Algebra, Topology, and Logic

In a category supplied with an $(\mathcal{E}, \mathcal{M})$-factorisation structure for sources, we consider reflective constant subcategories, i.e., subcategories which are closed under $\mathcal{M}$-sources and $\mathcal{E}$-images. We use these constant subcategories to study a general notion of constant morphism and use this to study left and right constant subcategories. The left and right constant subcategories generalises most torsion and torsion-free theories in categorical algebra. In a topological context, the left and right constant subcategories generalises subcategories of objects which have previously been seen as connected and disconnected or separated objects respectively. It can be shown that the right constant subcategories are reflective and with some assumptions it follows that the left constant subcategories are nearly multicoreflective. Different dual closure operators are constructed from subcategories and various adjunctions between dual closure operators and special subcategories are obtained. The adjunction, provided by the constant morphisms, between left and right constant subcategories factorises via these different constructions of dual closure operators.

Subgroup Commutativity Degree of Profinite Groups

E. Kazeem

University of Cape Town
kazeemfunmilayo@gmail.com

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

We find a probability measure which counts the pairs of closed commuting subgroups in infinite groups. This measure turns out to be an extension of what was known in the finite case as subgroup commutativity degree. The extremal case of probability one describes the so-called topologically quasihamiltonian groups and is a useful tool in describing the distance of a profinite group from this special class. We have been inspired by an idea of Heyer in the context of our problem.

References:

[1] P. Erdős and P. Turán, On some problems of a statistical group theory I, *Z. Wahrscheinlichkeitstheorie und Verw. Gebiete* **4** (1965), 175–186.

[2] S. Fisher and P. Gartside, On the space of subgroups of a compact group I, *Topology Appl.* **156** (2009), 862–871.

[3] H. Heyer, Probability measures on locally compact groups, Springer, Berlin, 2012.

Lagrangian formulation of a generalised coupled hyperbolic system

C. M. Khalique

International Institute for Symmetry Analysis and Mathematical Modelling, Department of Mathematical Sciences, North-West University, Mafikeng Campus, Private Bag X2046, Mmabatho 2735, Republic of South Africa
Masood.Khalique@nwu.ac.za

SAMS Classification: 11 **Lie Symmetries and Nonlinear DEs**

In this talk we carry out Noether classification of a generalised system of coupled hyperbolic equations. Several cases for the arbitrary functions are obtained which provide Noether symmetries for the system. These include linear, power, exponential and logarithmic functions. Moreover, we compute conservation laws corresponding to cases that have Noether symmetries..

The Finite Element Method for nonlinear Fredholm integral equation of the second kind

M. Khumalo*

University of South Africa
khumam@unisa.ac.za

A. Dlamini

University of South Africa
dlamia@unisa.ac.za

SAMS Classification: 16 **General Session**

In this paper, we consider a numerical solution for nonlinear Fredholm integral equations of the second kind. We work with uniform mesh and use the Lagrange polynomials together with the Galerkin finite element method, where the weight function is chosen in such a way that it takes the form of the approximate solution but with arbitrary coefficients. In the first instance, we discuss the implementation procedure for the finite element method, consider the existence and uniqueness of the solution, and consider an illustrative example. Finally, we consider the error analysis of the numerical method, and prove a theorem that shows that our implementation of the FEM for the nonlinear Fredholm integral equation of the second kind is Order 2 convergent.

Orthogonality in n-normed spaces

E. Kikianty

University of Pretoria
eder.kikianty@up.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

The notion of 2-normed spaces was introduced by S. Gähler in 1960's. Similar to how norms generalise the concept of length of vectors, the 2-norms ge-neralise that of area of the parallelogram spanned by two vectors. This notion may be extended to n-norms (for $n \geq 2$), which analogously becomes a gene-ralisation of the concept of volume of the parallelepiped spanned by n vectors. Many results for normed spaces have been extended to the setting of n-normed spaces. In this talk, I will give a brief introduction to these spaces, and focus on the concept of orthogonality, both in normed and n-normed spaces.

Applications of Delay Differential Equations to Foreign Exchange Reserves cycles

A.S. Kubeka*

University of South Africa
kubekas@unisa.ac.za

C. Malikane

University of the Witwatersrand
Christopher.Malikane@wits.ac.za

SAMS Classification: 12

Lie Symmetries and Nonlinear DEs

We develop a foreign exchange reserve model for a small open economy and we apply the theory of differential equations to model it and we solve the resulting general system of equations.

Representing and Jensen measures for D-characters

D.P. Blecher

University of Houston
dblecher@math.uh.edu

L.E. Labuschagne*

North-West University
louis.labuschagne@nwu.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

The primary focus of the talk is to show how key elements of the theory of uniform algebras may be extended to the noncommutative context. Recall that a D-character on a subdiagonal subalgebra of a unital weak* closed unital subalgebra A of a von Neumann algebra M, is a contractive homomorphism φ from A onto D which restricts to the self-map on D, where D is the self-adjoint portion of A. Such D-characters may be regarded as noncommutative analogues of multiplicative functionals. A "representing measure" of such a D-character would then be a positive weak* continuous extension of φ to all of M. We provide criteria for the existence of such representing measures, in the process also proving a noncommutative version of the Hoffman-Rossi theorem.

In closing we introduce the notion of noncommutative Jensen measures, and show that under very mild restrictions "representing measures" turn out to be Jensen measures.

Categorical Foundations for the Syntax of SOFiA

B.A. Laing*

Stellenbosch University
blaing@sun.ac.za

Z. Janelidze

Stellenbosch University
zurab@sun.ac.za

SAMS Classification: 01 **Categories, Algebra, Topology, and Logic**

SOFiA (short for Synaptic First Order Assembler) is a new logic syntax that aims to allow us bypass the need for logical quantifiers while also unifying internal and external inferences within the language. The syntax is built out of a monoidal category as opposed to the more algebraic approached used in classical logic. This change may also prove useful in the teaching of formal mathematics at the undergraduate level, as the physical presentation used in the syntax better aligns with the intuition of what an argument actually is.

In this talk we discuss the categorical machinery used to construct the foundations of this new syntax as well as explore written examples of the syntax.

Banach algebra techniques in Partial Differential Equations

W-S. Lee

North-West University
drwhasuck.lee@gmail.com

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Empathy theory uses a pair of evolution families $\langle S(t), E(t)\rangle$ to study *implicit* evolution equations of the form $\frac{d}{dt}[Bu(t)] = Au(t)$; $\lim_{t\to 0^+}[Bu(t)] = y \in Y$, where A and B denote non-closeable linear operators in a Banach space X to another Banach space Y.

Surprisingly, abstract Banach algebra techniques, like the factorization theorem, are crucial in (i) weakening the Hille-Yosida-like generation [1, Theorem 9] by removing the strong assumptions like the Radon-Nikodyn property [2, Theorem 4.1] and (ii) establishing empathy theory as a *non-closable representation* theory as opposed to the better known semigroup theory that is a bounded representation theory [2].

Equally surprisingly, abstract harmonic analysis is merged with Schwartz' vector-valued distributions to create a new convolution algebra $(\mathcal{A}_\Phi, *)$ of *admissible homomorphisms* which vectorizes Palmer's abstract convolution algebra [3, Chapter 1.9.7]. This framework replaces Schwartz' framework of vector-valued distributions which had limited success with strongly measurable intertwined evolution families.

This new framework extends the Feller convolution in order to handle two-space homogeneous Markov transition functions intertwined by the extended Chapman-Kolmogorov equation [4, equations (2.3) and (4.3)]. The two-space distributions are represented by $\mathbb{C}^2$-valued admissible homomorphisms, and their product expresses the uni-directional extended Chapman-Kolmogorov equation as an empathy relation. Their Fokker-Planck equations are described in terms of admissible homomorphisms as an implicit evolution equation. A pair of generators are involved as opposed to a single generator in classical Fokker-Planck equations [5].

References:

[1] N. Sauer, Empathy Theory and the Laplace transform. In: Linear Operators, Banach Center Publ., Inst. Math., Polish Acad. Sci., Warszawa **38** (1997), 325 – 338.

[2] W. Lee and N. Sauer, Algebraic approach to implicit evolution equations, *Bull. Pol. Acad. Sci. Math.*, Vol. 63, No. 1, 2015, 33–40 (presented by Professor Jan Kisyński).

[3] T. W. Palmer, Banach Algebras and The General Theory of *-Algebras; Volume I : Algebras and Banach Algebras, Encyclopaedia of Mathematics and its Applications, Cambridge University Press, New York, 1994.

[4] W. Lee and N. Sauer, Intertwined Markov Processes: Extended Chapman-Kolmogorov Equation, Accepted for publication in *Proc.Roy. Soc. Edinburgh Sect. A*.

[5] W-S Lee and C. Le Roux, Implicit convolution Fokker-Planck equations: Extended Feller convolution, *Proceedings of Semigroups Of Operators: Theory and Applications* (To appear).

[6] W. Lee and N. Sauer, Intertwined evolution operators, *Semigroup Forum*. (2017) 94:204-228 DOI 10.1007/s00233-016-9796-7.

p-quasimonotonicity in nonlinear elliptic and parabolic PDE's

T. Lin

University of Cape Town
lnxtia001@myuct.ac.za

SAMS Classification: 11 **General Session**

Variational approach is a very useful tool in qualitative study of partial differential equations, it allows us to study the solutions in a more general function space (so-called Sobolev space) to overcome the difficulties in classical method. Through variational formulation(also known as weak formulation), the partial differential equations can be written as an operator equation. Hence, the existence of weak solutions depends on the properties of the operator. In general, the operator needs to satisfy boundedness, growth, coercive and monotonicity assumptions. The existence result is well-known for case where the operator is monotone operator or pseudomonotone operator(in the sense of Brézis). Recently, a new type of monotonicity which is called p-quasimonotonicity has been introduced and applied to PDEs. This presentation provides an overview of the application of such monotonicity into Dirichlet problem for elliptic and parabolic system. The main tool used here is Young measure.

References:

[1] Hungerbühler, N., Young measures and nonlinear PDEs, Habilitationschrift ETH Zürich, 1999.

[2] Ball, John M., A version of the fundamental theorem for Young measures, *PDEs and continuum models of phase transitions*, Springer, pp. 207–215, 1989.

[3] Valdier, M., A course on Young measures, 1994.

Perturbation Ideals in Banach Algebras

T. Lukoto

University of Limpopo
tshikhudo.lukoto@ul.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Let $\mathcal{A}$ be a Banach algebra and let $R \subseteq \mathcal{A}$. Our concern is the set $P(R)$ which consists of all a in A such that $a + R \subset R$. We call $P(R)$ the perturbation ideal of R. In [1], it was proved that the perturbation ideal of the group of invertible elements in Banach algebra $\mathcal{A}$ is the radical of the Banach algebra. We expand this by showing more perturbation results which are also equal to the radical of the Banach algebra $\mathcal{A}$.

References:

[1] A. Lebow and M. Schechter, Semigroups of Operators and Measures of Non-compactness, *Journal of Functional Analysis* **7** (1971), 1–26.

Topologies and smooth structures on initial and final objects in the category of Frölicher spaces

B.M. Mahudu

University of the Witwatersrand
benmahudu@wits.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

The initial objects, in the category of Frölicher spaces, being studied are Frölicher subspace, product and equalizer's domain; and the final objects are Frölicher quotient, coproduct and coequalizer's codomain. For each object a canonical topology from the category of topological spaces is induced on the underlying set of the object, and Frölicher topologies are induced from the Frölicher structure. There are two Frölicher topologies for each object: a Frölicher topology induced from structure curves and a Frölicher topology induced from structure functions - it's shown that the former Frölicher topology is finer than the latter Frölicher topology for any Frölicher space. It's shown that for each initial object the canonical topology is coarser than the Frölicher topology induced from structure functions, and for each final object the canonical topology is finer than the Frölicher topology induced from structure curves. Furthermore we establish that the building structure for each object is constant and algorithmic.

On the Conatural classes of modules

P.R. Majozi*

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

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

The connection between hereditary torsion theories of an associative ring R and the lattice of all linear topologies on R has been studied extensively by many authors. The properties of this lattice determine several properties of R and category R-Mod of all R-modules. We refer to Golan for details of the study of this lattice and of hereditary torsion theories. The natural classes were introduced by Dauns under the name of saturated classes. The lattice of all natural classes in mod-R has been treated extensively in the recent years by Zhou and Dauns. The pre-natural classes and their lattices were introduced by Zhou. Later, Dauns and Zhou studied the sub-lattices of the prenatural classes. In this talk, we will discuss the conatural classes of modules in R-Mod.

References:

[1] P. E. Bland, Topics in Torsion Theory, *Mathematical Research*, vol. 103, Wiley VCH, Berlin, 1998.

[2] J. Dauns, Ideals, Natural Classes, and Functors, *Comm. Algebra* **38** (2010), 2240–2248.

[3] J. Dauns and Y. Zhou, Sublattices of the Lattice of Pre-natural Classes of Modules, *J. Appl. Algebra*, **231** (2000), 2240–2248.

[4] J. Dauns and Y. Zhou, Classes of Modules, Pure and Applied Mathematics, 281. Chapman & Hall/CRC, Boca Raton, FL, 2006.

[5] A. Alvarado-Garcia, H. A. Rincon-Mejia, and J. Rios-Montes, On the lattices of natural and conatural classes in R-mod, *Comm. Algebra*, **29**(2) (2001), 541–556.

[6] J. S. Golan, Torsion Theories, Pitman Monographs and Surveys in Pure and Applied Mathematics, vol. **29**, Longman Scientific and Technical, New York, 1986.

[7] B. Stenström, Rings of Quotients, Springer-Verlag, New York, 1975.

[8] Y. Zhou, Relative chain conditions and module classes, *Comm. Algebra* **25** (1997), 543-557.

[9] Y.Zhou, The lattice of pre-natural classes of modules, *J. Pure Appl. Algebra* **140** (1999), 191–207.

Chaotic wave packet spreading in the one- and two-dimensional disordered nonlinear Schrödinger equations

B. Many Manda*, B. Senyange and Ch. Skokos

Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701, South Africa
mnyber004@myuct.ac.za

SAMS Classification: 12 **General Session**

In the linear disordered Schrödinger equation, any compact wave packet remains localized for all times (Anderson localization - AL) [1]. Its fate when accouting nonlinear wave interactions is an intriguing topic, which has been extensively studied in theory, experiments and simulations (e.g., [2]). In these works it was observed that nonlinearity induces the thermalization of the wave packet surroundings leading to a slow subdiffusive spreading. Althrough we now understand that such spreadings are chaotic processes, the characteristics of this chaos still remains an open question.

In this talk, we present numerical results on the chaotic behavior of the wave packets spreading into the one- and two-dimensional discrete nonlinear Schrödinger equations, emphasizing the quantification of chaos strength through the calculation of the maximum Lyapunov exponent (mLE, [3] and references therein). Performing extensive numerical simulations for several initial wave packet profiles, disorder strengths and nonlinearities, we determine the characteristics of chaos for the different dynamical regimes encountered in these models. We emphasize the fact that the observed temporal power law of the mLEs is always $t^{-\alpha}$ with $\alpha \neq 1$ (we note that $\alpha = 1$ is seen in the case of regular motion). This is a clear indication that although the wave packet's dynamics becomes less chaotic in both models, it does not show any sign of crossing over to regular motion, which could imply the appearance of AL for the extended wave packet [4, 5].

References:

[1] P.W. Anderson, Absence of diffusion in certain random lattices, *Phys. Rev.* **109**, 1492–1505 (1958).

[2] S. Flach, D.O. Krimer, and Ch. Skokos, Universal spreading of wave packets in disordered nonlinear systems, *Phys. Rev. Lett.* **102**, 024101–024105 (2009).

[3] Ch. Skokos, The Lyapunov characteristic exponents and their computation, *Lect. Notes Phys.* **790**, 63-135 (2010).

[4] B. Senyange, B. Many Manda, and Ch. Skokos, Characteristics of chaos evolution in one-dimensional disordered nonlinear lattices, *Phys. Rev. E* **217**, 052229–052239 (2018).

[5] B. Many Manda, B. Senyange, and Ch. Skokos, Chaotic wave packet spreading in two-dimensional disordered nonlinear lattices, arXiv:1908.07594, 1-15 (2019).

Numerical solution of a system of non-linear reaction-diffusion equations

G.T. Marewo

North-West University
Private Bag X6001, Potchefstroom, 2520
gerald.marewo@nwu.ac.za

SAMS Classification: 16 **General Session**

In this study, we consider an initial-boundary value problem for a system of two nonlinear reaction-diffusion equations. Applications of such equations include population dynamics, image restoration and pattern dynamics to mention a few. Since the equations are nonlinear we seek a numerical solution. Discretisation in space is done using a Newton-Galerkin method. For discretisation in time, we make use of a compact finite difference scheme. Numerical experiments are performed to investigate the efficiency of the numerical method.

References:

[1] A. Madzvamuse, A. H. W. Chung, Fully implicit time-stepping schemes and non-linear solvers for systems of reaction-diffusion equations, *Applied Mathematics and Computation* 244 (2014) 361-374.

[2] X. Zhao, K. Huang, X. Wang, M. Shi, X. Zhu, Q. Gao, Z. Yu, Reaction-diffusion based image restoration, *Applied Mathematics and Computation* 338 (2018) 588-606.

Reductions and exact solutions of a cubic Schrödinger Partial Differential Equation

P. Masemola *

University of the Witwatersrand
Phetogo.Masemola@wits.ac.za

T. Phidane

University Of the Witwatersrand
462716@students.wits.ac.za

SAMS Classification: 16 **Lie Symmetries and Nonlinear DEs**

Lie symmetry analysis is an established method for generating symmetries of differential equations. We apply this method together with the generalized fundamental theorem of double reduction. In particular, Noether symmetries and some associated conservation laws are constructed in our investigation to find exact solutions of higher order partial differential equations and complex partial differential equations.

A Numerical Study of Entropy Generation in Nanofluid Flow Over an Inclined Cylinder

Z.M. Mburu *

Department of Mathematics, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa
mburum46@gmail.com

S.Mondal

Department of Mathematics, Amity University Kolkata, Newtown - 700135, West Bengal, India
sabya.mondal.2007@gmail.com

P. Sibanda

Department of Mathematics, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa
SibandaP@ukzn.ac.za

SAMS Classification: 11 **General Session**

In this study we present a numerical investigation of entropy generation, heat and mass transfer in an unsteady nanofluid flow over an inclined cylinder using Buongiorno's model. The system of highly non-linear partial differential equations modeling the flow is solved numerically using the overlapping grid spectral collocation method. The new numerical approach is computationally efficient and highly accurate. The influence of different flow parameters on entropy generation and other fluid properties is determined and the results presented in both qualitative and quantitative forms. The analysis on convergence of the numerical approach is done to show the accuracy and stability of the scheme. It was found that entropy generation can be regulated by increasing Brinkman number, Reynolds number, and magnetic number. The study can be used by engineers in the design of both heating and cooling of machines systems.

Towards computer verifiable proofs that are readable by humans

M. Messerschmidt

University of Pretoria
miek.messerschmidt@up.ac.za

SAMS Classification: 01 **General Session**

Proof assistants are meant to facilitate writing proofs of theorems which can be verified as correct by a computer. In the speaker's opinion, the main disadvantage to proof assistants is that they are designed for the computers who are doing the verifications. Proofs that can be verified by a proof assistant tend to be thoroughly arcane and therefore "write only". This, the speaker believes, is a major reason why so few humans use proof assistants.

This talk will briefly discuss how proof assistants work. We will present a proof of concept for a proof assistant implemented in Python, with its main goal being able to verify the correctness of proofs that are, in addition, also readable by humans.

On pathwise functional Ito calculus and stochastic integral representation of martingales

F.J. Mhlanga*

University of Limpopo
farai.mhlanga@ul.ac.za

S.C. Nkosi

University of Limpopo
siboniso.nkosi@ul.ac.za

SAMS Classification: 17 **General Session**

Hans Follmer [1] proposed a pathwise approach to Ito calculus and derived a change of variable ("Ito") formula for paths with finite quadratic variation along a sequence of partitions. Bruno Dupire [2] proposed a method to extend the Ito formula to a functional setting in a non-anticipative manner, using a pathwise functional derivative. Building on these ideas we develop a non-anticipative pathwise calculus for functionals defined on cadlag paths. This leads to a non-anticipative calculus for path-dependent functionals of a semimartingale, which is (in a precise sense) a "non-anticipative" equivalent of the Malliavin calculus. We construct a version of the martingale representation theorem which can be regarded as a non-anticipative form of the Clark-Haussmann-Ocone formula. The martingale representation formula allows to obtain an integration by parts formula for Ito stochastic integrals which enable in turn to define a weak functional derivative for a class of square-integrable martingales.

References:

[1] Follmer, H. (1981) Calcul d'Ito sans probabilités, Seminaire de Probabilités.

[2] Dupire, B. (2009): Functional Ito calculus. Portfolio Research Paper 2009-04, Bloomberg.

High order Hermite Collocation for Partial Differential Equations

Z. G. N. Mkhize

School of Mathematics, Statistics and Computer Science, UKZN
mkhizez2@ukzn.ac.za

SAMS Classification: 11

Lie Symmetries and Nonlinear DEs

In this paper, we derive the Hermite heptic basis functions and use them as trial functions to find the numerical solution to a time-dependent linear and non-linear pdes with consistent boundary conditions. The linear pde results in a matrix vector system while the non-linear pde results in a differential algebraic system. Collocation finite elements is applied to the spatial domain using Gauss points, while the unknown coefficients of the trial function carry the time-dependence. We present the results for linearized Kortewegde Vries (KDV) and Burgers equations.

Investigating the properties of regular motion in multidimensional nonlinear lattices by the Generalized Alignment Index (GALI) method

H.T. Moges*

Department of Mathematics and Applied Mathematics, University of Cape Town
mgshen002@myuct.ac.za

Ch. Skokos

Department of Mathematics and Applied Mathematics, University of Cape Town
haris.skokos@uct.ac.za

SAMS Classification: 12 **General Session**

One of the fundamental tasks in the study of dynamical systems is the discrimination between regular and chaotic behavior. Over the years several methods of chaos detection have been developed [1]. Modern numerical methods like the Smaller (SALI) and Generalized Alignment Index (GALI) [2] can be used for this purpose and are appropriate for investigating chaos and regular motion in high-dimensional systems [3, 4]. It has been observed that in multidimensional Hamiltonian models the constant values of the GALI for regular orbits decrease as the order of the index increases [4]. In this work, we numerically investigate the behavior of the GALIs in the neighborhood of simple periodic orbits (SPO's) [5] of the well-known Fermi-Pasta-Ulam-Tsingou (FPUT) lattice model [6]. In particular, we study how the values of the GALIs depend on the width of the stability islands and the systems energy. We also investigate the dependence of the GALIs on the initial distribution of the coordinated of the deviation vectors used for their computation.

References:

[1] Ch. Skokos, G. Gottwald, and J. Laskar (eds.). Chaos detection and predictability, Lect. Notes Phys., Vol. 915, Springer-Verlag, Berlin Heidelberg, 2016.

[2] Ch. Skokos and T. Manos. The Smaller (SALI) and the Generalized (GALI) alignment indices: Efficient methods of chaos detection, Lect. Notes Phys., 915, 129-181, 2016.

[3] Ch. Skokos, T.C. Bountis, and Ch. Antonopoulos. Geometrical properties of local dynamics in Hamiltonian systems: the Generalized Alignment Index (GALI) method. *Physica D*, 231, 30-54, 2007.

[4] Ch. Skokos, T.C. Bountis, and Ch. Antonopoulos. Detecting chaos, determining the dimensions of tori and predicting slow diffusion in Fermi-Pasta-Ulam lattices by the Generalized Alignment Index method, *Eur. Phys. J. Sp. Top.*, 165, 5-14, 2008.

[5] Ch. Antonopoulos and T.C. Bountis. Stability of simple periodic orbits and chaos in a Fermi-Pasta-Ulam lattice, *Phys. Rev. E* 73, 056206. 2006.

[6] E. Fermi, J. Pasta, and S. Ulam. Studies of Nonlinear Problem, LA-1940. Los Alamos National Laboratory. 1955.

Group Classification of a Generalized Coupled Hyperbolic LaneEmden System.

T.E Mogorosi

Sol Plaatje University
School of Natural and Applied Sciences
P/Bag X5008, Kimberley 8300, South Africa
tshepo.mogorosi@spu.ac.za

SAMS Classification: 11

Lie Symmetries and Nonlinear DEs

In this talk, we carry out a complete group classification of a generalized coupled hyperbolic Lane-Emden system. It is shown that the underlying system admits six-dimensional equivalence Lie algebra. We further show that the principle Lie algebra which is one-dimensional extends in several cases. We also carry out Lie reductions for some cases.

Construction of some designs invariant under the group $PSp_4(q)$

C. K. Mokalapa*

Department of Mathematics and Applied Mathematics, University of Limpopo
rresammy@gmail.com

A. Saeidi

Department of Mathematics and Applied Mathematics, University of Limpopo
saedi.amin@gmail.com

T. T. Seretlo

School of Mathematics and Computer Sciences, University of Limpopo
thekiso.seretlo@ul.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

In this talk, we construct some symmetric designs from the maximal subgroups and conjugacy classes of the Projective Symplectic group ($PSp_4(q)$, where q is a prime power) [2]. In [3], Key and Moori used two methods to construct combinatorial designs and codes from finite simple groups. We use method 1 to construct these symmetric designs from the maximal subgroups and conjugacy classes of $PSp_4(q)$. A transitive permutation group acting on combinatorial designs has important application in coding theory [4] and are useful tools in the decoding procedures. We shall consider the primitive permutation representation of simple groups to construct symmetric 1-designs. Our notation for designs follows as in [1].

References:

[1] E. F. Assmus Jr, and J. D. Key, Designs and Their codes. Cambridge Tracts in Mathematics, Vol. 103. Cambridge. 1992: Cambridge University Press (Second printing with corrections, 1993).

[2] O. H. King, The subgroup structure of finite classical groups in terms of geometric configuration, *Invent.Math.* pp 8. 1987.

[3] J. Moori, Finite groups, designs and codes. Information security, coding theory and related combinatorics, 202230, NATO Sci. Peace Secur. Ser. D Inf. Commun. Secur., 29, IOS, Amsterdam, 2011.

[4] J. Moori and A Saeidi. Some designs invariant under the Suzuki groups, *Util. Math.* 109 (2018), 105–114.

Lie group analysis of (3+1)-dimensional generalized BKP-Boussinesq equation

L.D. Moleleki

International Institute for Symmetry Analysis and Mathematical Modelling, Department of Mathematical Sciences, North-West University, Mafikeng Campus, Private Bag X2046, Mmabatho 2735, Republic of South Africa
Letlhogonolo.Moleleki@nwu.ac.za

SAMS Classification: 11 **Lie Symmetries and Nonlinear DEs**

In this talk we investigate (3+1)-dimensional generalized B-type KP-Boussinesq equation, which was recently formulated in the literature, from Lie group standpoint. Exact solutions and conservation laws of the aforementioned equation are obtained.

Modelling Heat Transfer Enhancement and Nanoparticles Distribution in Poiseuille Flow of a Reactive Nanofluid with Variable Properties

R.L. Monaledi*

Faculty of Military Science, Stellenbosch University, Private Bag X2, Saldanha 7395, South Africa.
amona@ma2.sun.ac.za

O. D. Makinde

Faculty of Military Science, Stellenbosch University, Private Bag X2, Saldanha 7395, South Africa.
makinded@gmail.com

SAMS Classification: 17 **General Session**

Abstract: Nanotechnology is a sizzling area of research due to its broad applications in electronics, thermal systems, agriculture, pharmaceutical medicine, chemical industry, and many others. In recent time, the emergence of nanotechnology-based heat transfer fluids known as nanofluid has augment functional success of the materials and facilitate new product development in industries and engineering. Nanofluid are colloidal suspension of nano-sized particles into the convention base fluid in order to exaggerate the thermophysical capability of base fluids. In this study, a more realistic modified Buongiorno's nanofluid model is proposed and utilised to examine the heat transfer enhancement, nanoparticles distribution, mechanisms of Brownian motion and microscopic thermophoresis of solid nanoparticles in a Poiseuille flow of water base reactive nanofluid through a microchannel. The governing nonlinear differential equations are obtained and tackled numerically by using shooting method coupled with Runge-Kutta-Fehlberg integration scheme. Graphical results showing the effects of the pertinent parameters on the nanofluid velocity, temperature, skin friction, Nusselt number and Sherwood number are presented and discussed quantitatively.

References:

[1] M. Venkateswarlu, M. Prameela, O.D. Makinde: Influence of heat generation and viscous dissipation on hydromagnetic fully developed natural convection flow in a vertical microchannel. *Journal of Nanofluids*, 8 (7), 1506-1516, 2019.

[2] R.L. Monaledi, O. D. Makinde: Entropy analysis of a radiating variable viscosity EG/Ag nanofluid flow in microchannels with buoyancy force and convective cooling.

Defect and Diffusion Forum, 387, 273Ű285, 2018.

[3] S. Das, R. N. Jana, O. D. Makinde: MHD flow of Cu-Al2O3/Water hybrid nanofluid in porous channel: Analysis of entropy generation. *Defect and Diffusion Forum*, Vol. 377, pp 42-61, 2017.

[4] S. Das, R. R. Patra, R. N. Jana, O. D. Makinde: Hall effects on unsteady MHD reactive flow through a porous channel with convective heating at the Arrhenius reaction rate. *Journal of Engineering Physics and Thermophysics* Vol. 90(5), 1178-1191, 2017.

[5] M.H. Mkwizu, O.D. Makinde: Entropy generation in a variable viscosity channel flow of nanofluids with convective cooling: *Comptes Rendus Mécanique*, Vol. 343, 38-56, 2015.

.

Application of Parallel Multigrid Methods to Compressible Flow Simulations

S.N. Neossi-Nguetchue

Namibia University of Science and Technology, Windhoek, Namibia
sneossi@nust.na

G.M. Moremedi*

University of South Africa, Florida campus, South Africa
moremgm@unisa.ac.za

SAMS Classification: 13 **General Session**

In this paper, we investigate the acceleration of convergence of the finite volume method applied to compressible laminar flows using parallel multigrid method. V-cycle at various levels with three different smoothers, namely Jacobi, Gauss-Seidel and SOR in conjuction with their parallel implementations, are used and compared. It is observed that combining multigrid methods with parallel implementation of a serial code contributes significantly in improving the performance of the underlying solver.

References:

[1] P. Wesseling, 1992. An Introduction to Multigrid Methods. Wiley

[2] P. Pacheko, 2011. An Introduction to Parallel Programming. Kaufmann.

r-Fredholm theory in Banach algebras

S. Mouton

Stellenbosch University
smo@sun.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

The introduction of Fredholm theory relative to general unital homomorphisms $T : A \to B$ between Banach algebras A and B was due to Robin Harte [5], after which this investigation was continued by several authors. Motivated by results of Egor Alekhno in [1] and [2], the *upper Browder* elements in an ordered Banach algebra (OBA) were introduced in [3], thereby initiating the study of the interplay between Fredholm theory and ordering.

Inspired by an indication that these elements could be useful in the context of OBAs, certain variants of the invertible, Fredholm and Browder elements (namely the r-invertible, r-Fredholm and r-Browder elements) were investigated in [4] in the context of general Banach algebras, and analogues of Harte's results were obtained.

In this talk I will give an overview of the development of r-Fredholm theory, which is joint work with Ronalda Benjamin and Niels Jakob Laustsen.

References:

[1] E. A. Alekhno: Some properties of essential spectra of a positive operator. *Positivity* 11 (2007), 375–386.

[2] E. A. Alekhno: Some properties of essential spectra of a positive operator. II. *Positivity* 13 (2009), 3–20.

[3] R. Benjamin and S. Mouton: Fredholm theory in ordered Banach algebras. *Quaest. Math.* 39 (2016), 643–664.

[4] R. Benjamin, N. Laustsen and S. Mouton: r-Fredholm theory in Banach algebras. *Glasgow Math. J.* 61 (2019), 615–627.

[5] R. E. Harte: Fredholm theory relative to a Banach algebra homomorphism. *Math. Z.* 179 (1982), 431–436.

Finite groups containing blocks, characters and elements, all of defect zero

Z.E. Mpono*

UNISA
mponoze@unisa.ac.za

S.G. Nkosi

UNISA
snkosi044@gmail.com

SAMS Classification: 02 **General Session**

From a character table of a finite group, blocks of characters are obtained. Sometimes some finite groups would possess amongst the blocks, those of defect zero and sometimes not. The object here is to study finite groups which possess blocks, characters and elements, all of defect zero.

On J-Spaces and their Compactitions

S.S. Mthethwa

University of KwaZulu-Natal
simomthethwathwa@gmail.com

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

The study of J-spaces was introduced by E. Michael in [1]. In this presentation, we intend to exhibit the theory of J-frames by introducing the lattice theoretic point of view of J-spaces. Conditions under some compactifications of a J-frame are perfect will be discussed.

References:

[1] E. Michael, J-spaces, *Topology Appl.* **102** (2000), no. 3, 315-339.

Insurer Risk Management via Stochastic Control

T. Bosch

South African Reserve Bank, Bank Supervision Department
thahir.bosch@yahoo.com

M.P. Mulaudzi*

University of South Africa, Department of Decision Sciences
mulaump@unisa.ac.za

SAMS Classification: 10, 11 **General Session**

In this paper, we will solve a problem that involves the minimization of certain risks associated with the operation of insurance companies. Insurers bear premium and equity risks that involve the stability of sources of insurer funds and the security of the assets held, respectively. In particular, we investigate the optimal premium rate maintained and asset allocation strategy adopted by an insurer that aims to maintain actuarially determined operating levels. Here we make use of the actuarial funding method to specify cost functions that describe the stochastic dynamics of these levels. This situation leads naturally to a nonlinear stochastic optimal control problem whose solution is based on the dynamic programming algorithm. Furthermore, we will introduce a spread method for insurers that will be found to be optimal for the adjustment of the operating levels. Throughout the paper we concentrate on the type of insurer that pays a pre-determined claim at a given time.

Global dynamics of a delayed cholera model with treatment

J.M.W. Munganga*

Department of Mathematical Sciences
University of South Africa
mungajmw@unisa.ac.za

A. S. Hassan

Department of Mathematical Sciences
University of South Africa
shituha@unisa.ac.za

SAMS Classification: 12,17

General Session

A delay differential equation-cholera model with infection from aquatic reservoir only and environmental disinfection as intervention is formulated and analyzed. Basic properties of the model that ascertain its mathematical and epidemiological well-posedness are proved. Unique disease free and cholera endemic equilibria are found, further the control reproduction number is calculated. The local and global stabilities of the equilibria are found to depend on the control reproduction number and delay as threshold quantities. Disinfection effect is shown to increase the number of healthy individuals and decrease the concentration of cholera in the environment, while the infected humans remain unchanged. Numerical simulations are conducted to further verify the theoretical results.

Split extensions of preordered groups

E. N. Muteti

University of Cape Town
evelyn.nzilani@gmail.com

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

It is well known that every split epimorphism of groups is (up to isomorphism) a semidirect product projection. According to a more precise categorical formulation, the semidirect product construction determines a category equivalence between group actions on groups and split extensions of groups. We extend this result to preordered groups, and give examples, some of which are suggested by [1].

References:

[1] M. M. Clementino, N. Martins-Ferreira, and A. Montoli, On the categorical behaviour of preordered groups, *J. Pure Appl. Algebra* 223, 10, (2019), 4226-4245

A Pick matrix criteria for Lyapunov domination

A. Naudé*

North-West University
naudealma@gmail.com

S. ter Horst

North-West University
sanne.terhorst@nwu.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Let $\mathbb{S}_n$ (resp. $\mathbb{P}_n$) denote the sets of symmetric (resp. positive definite) matrices in $\mathbb{R}^{n\times n}$ and $A \in \mathbb{R}^{n\times n}$ with eigenvalues λ_j such that

$$\lambda_i + \lambda_j \neq 0, \quad 1 \leq i, j \leq n.$$

For $B \in \mathbb{R}^{n\times n}$ we say that B Lyapunov dominates A, denoted by $A \leq_{\mathfrak{L}} B$, if

$$S \in \mathbb{S}_n, \qquad SA + A^H S \in \mathbb{P}_n \quad \Longrightarrow \quad SB + B^H S \in \mathbb{P}_n.$$

The Lyapunov order, along with other matrix inequalities, plays an important role in linear systems and control theory. Define

$$\mathcal{C}_{\mathfrak{L}}(A) := \left\{ B \in \mathbb{R}^{n\times n} : A \leq_{\mathfrak{L}} B \right\}.$$

This subset forms a convex invertible cone (**cic**) in $\mathbb{R}^{n\times n}$, that is, a convex cone of matrices which is closed under inversion. For the smallest **cic** containing A, denoted by $\mathcal{C}(A)$, we have

$$\mathcal{C}(A) \subseteq \mathcal{C}_{\mathfrak{L}}(A) \cap \{A\}''_{\mathbb{R}}, \tag{1}$$

with $\{A\}''_{\mathbb{R}}$ the real bicommutant of A. In [1] Cohen and Lewkowicz conjectured that the two **cic**s in (1) coincide. In this talk we present a Pick matrix type criteria for $B \in \mathbb{R}^{n\times n}$ to be in $\mathcal{C}_{\mathfrak{L}}(A) \cap \{A\}''_{\mathbb{R}}$.

References:

[1] N. Cohen and I. Lewkowicz. The Lyapunov order for real matrices. *Linear Algebra Appl.* 430 (2009), no. 7, 1849–1866.

Hosoya polynomial of the subdivided join

T.P. Ncambalala*

School of Mathematics, University of the Witwatersrand, P/Bag 3, WITS, 2050, RSA
Thokozani.Ncambalala@wits.ac.za

E.G. Mphako - Banda

School of Mathematics, University of the Witwatersrand, P/Bag 3, WITS, 2050, RSA
Eunice.Mphako-Banda@wits.az.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

The Hosoya polynomials of diameter 1 and diameter 2 graphs are known. We extend the concept of a vertex join of a graph to a subdivided join of a graph. Then we give the formula of the Hosoya polynomial of a subdivided join of a complete graph and the formula of the Hosoya polynomial of a subdivided join of diameter 2 graphs.

On the notion of ranked complementation in a lattice

F.K. van Niekerk

Stellenbosch University
16448553@sun.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

The notion of an n-complement, where n is a natural number, is a generalization of a complement in a lattice. This notion was first discovered while studying subgroup lattices of finite abelian groups. The main result of this talk will be to characterize which modular lattices having finite height are n-complemented. We will also show some relations between pseudocomplements, which is a well-know generalization of complementation, and n-complements.

Embeddings for spherically symmetric spacetimes

A. Nikolaev*

Astrophysics and Cosmology Research Unit, School of Mathematics, Statistics and Computer Science University of KwaZulu–Natal, Private Bag X54001, Durban 4000, South Africa
ilc@xhns.org

S.D. Maharaj

Astrophysics and Cosmology Research Unit, School of Mathematics, Statistics and Computer Science University of KwaZulu–Natal, Private Bag X54001, Durban 4000, South Africa
maharaj@ukzn.ac.za

SAMS Classification: 13 **General Session**

Locally a four-dimensional pseudo-Riemannian spacetime can be isometrically embedded into a higher dimensional Euclidean space. The embedding gives a deeper insight into the geometry of the manifold and may provide new solutions to the field equations. Our objective is to consider embedding in spherically symmetric spacetimes in a general setting. The only condition is that spacetime should be spherically symmetric and of embedding Class I. We do not make any other assumptions and apply only the embedding equations of Gauss-Codazzi-Ricci. In the case when the embedding condition could not be solved in general we use the Lie point symmetries method to obtain invariant solutions. Some interesting spacetime metrics are obtained.

A shifted Chebyshev spectral collocation method for fractional differential equations

N.S. Nkomo*

School of Mathematics, Statistics and Computer Science, University of KwaZulu-Natal, Pietermaritzburg, South Africa.
211558670@stu.ukzn.ac.za

P. Sibanda

School of Mathematics, Statistics and Computer Science, University of KwaZulu-Natal, Pietermaritzburg, South Africa.
sibandap@ukzn.ac.za

SAMS Classification: 16 **General Session**

In this study, we use the shifted Chebyshev spectral collocation to solve fractional differential equations (FDEs). These differential equations have non-integer order derivatives. The non-integer operator presents additional complexity in fractional calculus and accurate numerical methods are required when solving FDEs. Several numerical methods such as the fractional Adomian decomposition method, the Galerkin collocation method, the homotopy perturbation method, the homotopy analysis, finite difference and finite element methods have been used to solve FDEs. Orthogonal polynomials such as Jacobi and Legendre are used together with Chebyshev collocation in the derivation of spectral differentiation matrices for FDEs. We apply the method to the non and fractional Bagley-Torvik equation and an inhomogeneous linear equation. The numerical results are compared with exact solutions to confirm the accuracy of the method. Our numerical results confirm the convergence of the fractional collocation method.

Higher order generalised geometric polynomials

S. Nkonkobe

Department of Mathematical Sciences, Sol Plaatje University, Kimberly, 8301, snkonkobe@gmail.com

SAMS Classification: 14 **Graph Theory and Combinatorics**

Inserting bars in-between blocks of a preferential arrangement forms a barred preferential arrangement. We study a generalisation of barred preferential arrangements by making use of the generalised Stirling numbers (Hsu & Shiue 1998). Combinatorial properties of these generalised barred preferential arrangements are studied.

On pathwise hedging of path-dependent options

S.C. Nkosi*

Department of Mathematics and Applied Mathematics, University of Limpopo, South Africa
siboniso.nkosi@ul.ac.za

F.J. Mhlanga

Department of Mathematics and Applied Mathematics, University of Limpopo, South Africa
farai.mhlanga@ul.ac.za

SAMS Classification: 17 **General Session**

Functional Itô is based on an extension of the classical Itô calculus to functionals depending on the entire past evolution of the underlying paths and not only on its current value. The calculus builds on Föllmer's deterministic proof of the Itô formula [1] and a notion of pathwise functional derivative recently proposed by Dupire [2]. There are no smoothness assumptions required on the functionals, however, they are required to possess certain directional derivatives which may be computed pathwise [3]. In practice an agent does not know the distribution of the underlying asset for sure but has statistical information on the distribution. The agent observes the path of the stochastic process, then it is natural that the hedging decisions be based on the observed path. In this talk, we use the functional Itô calculus to show that the hedging strategy is not only robust in the model $\mathcal{M}_\sigma$ for the functional F but also for the functional form of the path dependence of certain derivatives. We show that hedging strategy exists pathwise for continuous martingale, i.e. the Black-Scholes hedging strategies remain hedges also when a zero quadratic variation process is added to the driving continuous semimartingale.

References:

[1] H. Föllmer: Calcul d'Itô sans probabilités. In *Séminaire de Probabilités XV*, 1979/80. 143–150. Springer. 1981.

[2] B. Dupire: Functional Itô calculus. 2009.

[3] R. Cont and D-A. Fournié: Functional Itô calculus and stochastic integral representation of martingales. *Annals of Probability*. Vol. 41. No. 1. 109–133. 2013.

Convective instability of a multicomponent-diffusive convective in a rotating cylindrical annulus

O. A.I. Noreldin*

osman@aims.edu.gh

P. Sibanda

sibandap@ukzn.ac.za
School of Mathematics, Statistics & Computer Science University of KwaZulu-Natal
Private Bag X01
Scottsville
Pietermaritzburg 3209
South Africa

SAMS Classification: 13 **General Session**

In this talk, we investigate thermal convective instabilities in the form of thermal Rossby waves in a cylindrical annulus rotating about its axis of symmetry. The annulus is heated from outside and filled with three-component fluids with different molecular diffusivities. The conditions for the onset of the critical Rayleigh number for thermal Rossby wave is derived and the influence of parameters such as Prandtl number, Coriolis force and concentration Rayleigh numbers on the onset of convection are discussed.

References:

[1] R.D. Simitev, Double-diffusive convection in a rotating cylindrical annulus with conical caps, *Physics of the Earth and Planetary Interiors*, 186: 183–190, 2011.

[2] R.W. Griffiths, The influence of a third diffusing component upon the onset of convection, *Journal of Fluid Mechanics*, 92: 659–670, 1979.

[3] F.H. Busse, Is low Rayleigh number convection possible in the Earth's core, *Geophysical Research Letters*, 29: 1105, 2002.

[4] J.S. Turner, Multicomponent convection, *Annual review of fluid mechanics*, 17: 1-44, 1986

Non-classical symmetry analysis of a convection-dispersion equation

B.P. Ntsime

University of Johannesburg
paulinen@uj.ac.za

SAMS Classification: 12,16

Lie Symmetries and Nonlinear DEs

Symmetry methods provides diverse and ad hoc integration techniques to solve the reduced ordinary differential equation. These methods are interesting as they provide the exact solutions of non-linear equation. In this paper, we look at the time-dependent convection-convection equation. Interactive MAPLE routine GENDEFNC and the DESOLVE package are used to provide the special classical symmetries.

First steps for exceptional isomorphisms between Azumaya algebras

R. N'gambi

University of Pretoria
rngambi1329@gmail.com

P.P. Ntumba*

University of Pretoria
patrice.ntumba@up.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

We start by considering Azumaya R-algebras of finite rank, where R is a local ring. Then, we show that there is a bijection between the set of equivalence classes of nonsingular bilinear forms on any given Azumaya R-algebra A modulo multiplication by a unit of R and the set of adjoint anti-automorphisms of $End_R(A)$. Furthermore, under this same isomorphism, the R-linear involutions of $End_R(A)$ correspond to nonsingular bilinear forms which are either symmetric or skew-symmetric.

Modelling health policy changes: The case of HIV/AIDS

F. Nyabadza

University of Johannesburg
fnyabadza@uj.ac.za

SAMS Classification: 12 **General Session**

The management and treatment of HIV/AIDS has gone through significant changes in the past three decades. In the same vain, a significant number of mathematical models have been developed over the same period. One then asks; have the models been adapting to the change of policies? In the presentation we look at the role played by mathematical models in shaping the control and management of HIV/AIDS and suggest ways to model the changes in policies, that have occurred over the years. The results have a significant impact in influencing how models should relate to data in an epoch where policies evolve.

A numerical study of kink-soliton interactions of the Gardner equation

C.P. Olivier

North-West University: Mafikeng Campus
carel.olivier@nwu.ac.za

SAMS Classification: 11

Lie Symmetries and Nonlinear DEs

The Gardner equation (also known as the mixed KdV-mKdV equation) has both soliton and kink solutions, provided that the coefficient of the cubic nonlinear term is negative. In this talk, we investigate collisions between kinks and solitons numerically. The unique features of these interactions are shown to be consistent with an asymptotic analysis. Possible applications to space physics are briefly considered.

On coproducts of internal categories in the category of commutative rings

K. A. Olurode

University of Cape Town
olurodekaa@gmail.com

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

Let $\mathcal{C}$ be the category of commutative (non-unital) rings. Using a well-known description of finite coproducts of M-objects in $\mathcal{C}$, where M is a monoid, we give a simplified description of finite coproducts of internal categories in $\mathcal{C}$.

Analysis of exponentially decaying internal heat generation on MHD nanofluids over an isothermal stretching sheet: A numerical study

I. S. Oyelakin*

School of Mathematics, Statistics and Computer Science
University of KwaZulu-Natal, Private Bag X01, Scottsville,
Pietermaritzburg, 3209, South Africa
oyelakini@ukzn.ac.za

O. Adeyeye

Department of Mathematics, School of Quantitative Sciences,
Universiti Utara Malaysia, Sintok, 06010, Kedah, Malaysia
adeyeye@uum.edu.my

P. Sibanda

School of Mathematics, Statistics and Computer Science
University of KwaZulu-Natal, Private Bag X01, Scottsville,
Pietermaritzburg, 3209, South Africa
sibandap@ukzn.ac.za

SAMS Classification: 13 **General Session**

In this study, we present the newly developed block methods and use it to solve equations describing the hydromagnetic flow and heat transfer of a viscous nanofluid moving over an isothermal stretching sheet. The study considers an exponentially decaying internal heat generation as well as a free nanoparticle movement on the concentration boundary. The solutions are verified using the spectral local linearization method and a validation of the results is presented by comparing the current results with those of existing literature.

Existence and convergence results for monotone nonexpansive type mappings in hyperbolic metric space

R. Pant

Department of Mathematics and Applied Mathematics, University of Johannesburg, Auckland Park 2006, South Africa
rpant@uj.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

We present some fixed point results for nonexpansive type mappings in hyperbolic metric spaces. Indeed, we present some existence and convergence results for wider classes of nonexpansive type mappings. We also discuss a number of examples to show the generality of the mappings considered herein.

References:

[1] B. A. Bin Dehaish and M. A. Khamsi, Browder and Göhde fixed point theorem for monotone nonexpansive mappings, *Fixed Point Theory Appl.* **20** (2016) 1–9.

[2] U. Kohlenbach, Some logical metatheorems with applications in functional analysis, *Trans Amer Math Soc.* **357** (2005), no. 1, 89–128.

[3] R. Pant and R. Pandey, Existence and convergence results for a class of nonexpansive type mappings in hyperbolic spaces. *Appl. Gen. Topol.* **20** (2019), no. 1, 281–295.

[4] R. Shukla, R. Pant, Z. Kadelburg and H. K. Nashine, Existence and convergence results for monotone nonexpansive type mappings in partially ordered hyperbolic metric spaces. *Bull. Iranian Math. Soc.* **43** (2017), no. 7, 2547–2565.

[5] R. Shukla, R. Pant and P. Kumam, On the α-nonexpansive mapping in partially ordered hyperbolic metric spaces. *J. Math. Anal.* **8** (2017), no. 1, 1–15.

[6] T. Suzuki, Fixed point theorems and convergence theorems for some generalized nonexpansive mappings, *J Math Anal Appl.* **340** (2008) 1088–1095.

[7] W. Takahashi,A convexity in metric space and nonexpansive mappings, *I. Kodai Math Sem Rep.* **22** (1970) 142–149.

Equi-eccentric maximal planar subgraphs of maximal planar graphs

R.M. Casablanca

Departamento de Matemática Aplicada I, Universidad de Sevilla

P. Dankelmann

Department of Mathematics, University of Johannesburg

B.K. du Preez*

Laboratory for Discrete Mathematics and Theoretical Computer Science, Department of Mathematics and Applied Mathematics, University of Cape Town
brandondup@gmail.com

D.J. Erwin

Laboratory for Discrete Mathematics and Theoretical Computer Science, Department of Mathematics and Applied Mathematics, University of Cape Town

SAMS Classification: 14 **Graph Theory and Combinatorics**

If a graph H is a subgraph of a graph G, then H is said to be an equi-eccentric subgraph of G when all vertices of H have equal eccentricity in G. For example, the center and periphery of a graph are equi-eccentric subgraphs of that graph. Let $H = (V, E)$ be a graph. If S is a subgraph of H, then the quasi-eccentric set of S, denoted $\mathtt{Qcc}(S)$, is defined as follows:

$$\mathtt{Qcc}(S) = \{u \in V : (\forall v \in V)(\exists s \in V(S)) \text{ such that } d(u,s) \geq d(v,s)\}.$$

If H is a plane graph, and f is a face of H, then the subgraph of H induced by f, denoted $H[f]$, is the subgraph of H consisting of all vertices and edges of H which lie on the topological boundary of f. In [1], it is shown that there exists a maximal plane graph G containing the maximal plane graph H as an equi-eccentric subgraph if and only if for every vertex u of H there exists a face f_u of H such that u is in $\mathtt{Qcc}(H[f_u])$. In this talk, we sketch a proof of the aforementioned result.

References:

[1] R.M. Casablanca, P. Dankelmann, D.J. Erwin and B.K. du Preez, Centers of Planar and Maximal Planar Graphs, unpublished manuscript.

The projective characters of the maximal subgroups of the Mathieu group M_{12}

A.L. Prins

Department of Mathematics and Physics, Faculty of Applied Sciences, Cape Peninsula University of Technology, PO Box 1906, Bellville, 7535
prinsab@cput.ac.za or abrahamprinsie@yahoo.com

SAMS Classification: 02 **General Session**

The finite sporadic simple Mathieu group M_{12} has 11 conjugacy classes of maximal subgroups [1]. The ordinary irreducible characters of each maximal subgroup G of M_{12} are already known and uploaded in the computer algebra system GAP [2]. The purpose of this presentation is to determine the Schur Multiplier $M(G) \cong H^2(G, \mathbb{C}^*)$ of each maximal subgroup G of M_{12} and hence to compute the set of irreducible projective characters $\mathrm{IrrProj}(G, \alpha)$ of G associated with a factor set α in a cohomology class $[\alpha]$ of $H^2(G, \mathbb{C}^*)$. The author make use of appropriate GAP codes developed in [3] and other techniques found in [4] to help in the computation of these sets $\mathrm{IrrProj}(G, \alpha)$ of irreducible projective character tables.

References:

[1] J.H. Conway, R.T. Curtis, S.P. Norton, R.A. Parker, and R.A. Wilson, Atlas of Finite Groups, Oxford University Press, Oxford, 1985.

[2] The GAP Group, GAP --Groups, Algorithms, and Programming, Version 4.6.3; 2013. (http://www.gap-system.org).

[3] A.L. Prins, The projective character tables of a solvable group $2^6{:}(6 \times 2)$, *International Journal of Mathematics and Mathematical Sciences*, Article ID 8684742, accepted.

[4] A.L. Prins, The character table of an involution centralizer in the Demp-wolff group $2^{5\cdot}GL_5(2)$, *Quaestiones Mathematicae* **39** (2016), 561-576.

Behaviour of sublocales, in particular joins of closed ones

A. Pultr

Charles University, Prague, Czech Republic
pultr@kam.mff.cuni.cz

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

Sublocales as natural subobjects in generalized topology.

Aside: In classical spaces we have typically more sublocales than subspaces. It is useful (intuitive example to be presented).

The coframe of sublocales $\mathsf{S}(L)$.

Open and closed sublocales, they are what they should be.

Subfitness and fitness.

History of subfitness, Isbell's different approach.

Somewhat surprising fact: All closed sublocales are meets of open ones iff all sublocales whatsoever are meets of open ones.

Basic question: What about joins of closed sublocales? Here we do not have an analogon with the fact on the meets of opens. But the system $\mathsf{S}_c(L)$ of all joins of closed sublocales turned out to be of particular interest.

Aside: If $\mathsf{S}_c(L) = \mathsf{S}(L)$ we obtain scattered L, not subfit ones.

Facts:

- $\mathsf{S}_c(L)$ is always a frame,
- (precisely) for subfit L, $\mathsf{S}_c(L)$ is a Boolean algebra, and we have a natural embedding $L \to \mathsf{S}_c(L)$ suitable for the study of non-continuous maps,
- for T_1 spaces X, $\mathsf{S}_c(\Omega(X))$ picks from $\mathsf{S}(\Omega(X))$ precisely the subspaces,

and more.

Lifting and the lifting problem.

Comparison with $\mathsf{S}(L)$ resp. $\mathsf{S}(L)^{\mathrm{op}}$.

A glimpse from algebra: frames of special filters, $\mathrm{Filt}_{\mathsf{E}}(L) \cong \mathsf{S}_c(L)$, some more.

Towards the definable (p, q)-conjecture

T.O. Rakotonarivo*

Stellenbosch University
tsinjo@sun.ac.za

G. Boxall

Stellenbosch University
gboxall.ac.za

SAMS Classification: 01

Categories, Algebra, Topology, and Logic

The definable (p, q)-conjecture is a model-theoretic version of a (p, q)-theorem in combinatorics, which was conjectured in the form of a question by Chernikov and Simon in 2015. Boxall and Kestner, in 2018, proved that the conjecture stands for distal theories. Knowing that real closed fields are distal and dense pairs of real closed fields are not, we investigate such pairs to extend the work towards the definable (p, q)-conjecture.

In this talk, I will present an overview of some relevant concepts from model theory. Then I will give some facts about real closed fields and dense pairs of real closed fields. Finally, I will discuss partial results towards the definable (p, q)-conjecture for dense pairs of real closed fields.

Sparse random acyclic digraphs

D Ralaivaosaona

Stellenbosch University
naina@sun.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

Let $\mathcal{D}(n, p)$ denote the probability space of random digraphs (directed graphs) defined in the following way: First, each of the $\binom{n}{2}$ possible edges on a given set of n vertices is included with probability $2p$, where all edges are independent of each other. Thereafter, a direction is chosen independently for each of the edges. Each direction has probability $\frac{1}{2}$. The result is a simple digraph on n vertices. We are interested in the probability that a random instance of $\mathcal{D}(n, p)$ is *acyclic*, i.e. it does not contain a directed cycle. In 1988, Bender, Richmond, Robinson and Wormald, considered a similar problem for the dense case i.e. p is bounded below by some positive constant. I will talk about the probability that $\mathcal{D}(n, p)$ is acyclic but in the sparse regime, that is when $p = \lambda/n$ for a fixed real number $\lambda > 0$. This is a joint work with Vonjy Rasendrahasina of the University of Antananarivo and Stephan Wagner of Stellenbosch University.

Internal categories in the category of groups with multiple operators

S. Ranchod

University of Cape Town
rncsan003@myuct.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

Porter [1] considers the category of "groups with operations", $\mathbb{C}$. A group with operations can be seen as a special case of a group with multiple operators, as defined in by Higgins [2], that is, an algebraic structure with an underlying group structure satisfying certain additional conditions. Porter then considers an internal category inside this category and establishes an equivalence between the category of internal categories in $\mathbb{C}$, $\mathbf{Cat}(\mathbb{C})$, and the category of suitably defined crossed modules in $\mathbb{C}$, $\mathbf{XMod}(\mathbb{C})$. We investigate the conditions which define these groups with operations and the equivalence between these two categories to find alternative conditions under which the equivalence can be established.

References:

[1] T. Porter, Extensions, crossed modules and internal categories in categories of groups with operations, *Proceedings of the Edinburgh. Math. Soc.* **30**(3) (1987), 373-381.

[2] P. J. Higgins, Groups with multiple operators, *Proceedings of the London Mathematical Society* **3**(6) (1956), 366–416.

An extension of the Alladi-Schur Theorem

M.O. Rapudi

University of Witwatersrand, Johannesburg
942365@students.wits.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

In [1], George Andrews recalls a theorem of Schur, and also reports a hint from K. Alladi. We observe a version of the Alladi-Schur theorem which states that the number of partitions of n into distinct parts not divisible by 3 is equal to the number of partitions of n into odd parts occuring not more than twice. In this talk we give a simple extension of this result, present bijections in certain cases and derive some parity and recurrence formulas of related partition functions.

References:

[1] G.E. Andrews, A refinement of the Alladi-Schur Theorem. *Proceed. Lattice Path Conf.*, Dev. in Math. series. To appear.

[2] G.E. Andrews, Theory of Partitions, Cambridge University Press, 1984.

A diameter on a connected locally connected metric frame

C. Rathilal

University of Johannesburg
crathilal@uj.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

In this talk, we present the construction and properties of a new diameter, ρ, on a connected locally connected metric frame (L, d). The constructed diameter is the analogue of Kelley's metric from [1]. We will show that this diameter successfully answers a question of Whyburn from [2], in the point-free context. Using the approach of Pultr [2], we obtain a metric diameter $\tilde{\rho}$ on L from ρ, with property that $\tilde{\rho} \leq \rho$. The significance of $\tilde{\rho}$ is discussed and its relevance to the theory of Peano frames.

References:

[1] J. L. Kelley., A Metric Connected with Property S, *American Journal of Mathematics*, Vol. 61, No. 3, 1939, pp 764-768.

[2] J. Picado and A. Pultr, Frames and Locales, Springer, Basel, 2011.

[3] G. T. Whyburn, A certain transformation on metric spaces, *American Journal of Mathematics*, vol. 54 (1932), pp367 - 376.

Advantages and Disadvantages of Technological Advances in Mathematics Education

F. Ratshisindi

University of Limpopo
f.ratshisindi@gmail.com

SAMS Classification: 18

General Session

The relationship between technological advances and mathematics education has surely been a positive one in terms of simplicity and improving the speed of delivery of the content. However, attention is not given to what is lost when the teaching of mathematics is reliant on technological advances compared to the traditional teaching methods. This paper aims to outline disadvantages of technological advances in the teaching of mathematics. We also provide counter methods to minimise (even eliminate) the negative impact of technological advances on the teaching of mathematics and the development of mathematics as a discipline. We also give a summary of advantages of the technological advances and how they can be implemented in the teaching of mathematics in such a way that nothing is lost.

Salbany compactification

A.D. Razafindrakoto

University of the Western Cape
arazafindrakoto@uwc.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

Salbany described in [1] a method of obtaining a completion of a (quasi-) uniform space by embedding it into a space of Cauchy filters. The construction itself is part of a monad, so-called *completion monad*, and exhibits the complete (quasi-) uniform spaces as algebras. The construction is essentially repeated in the latter article [2], but in this case general topological spaces are considered with ultrafilters. However, Salbany avoided mentioning the word *monad* in the latter although it is transparent from the construction that one is in presence of the ultrafilter monad.

The talk that I shall present will first describe this monad and then try to retrace the path that Salbany may have followed had he attempted to reproduce the setting in [1]. I shall also give various descriptions of the properties of the ultrafilter space.

References:

[1] S. Salbany, The completion monad and its algebra, *Comm. Math. Univ. Carol.* 23 (1982) no. 2, 301–311.

[2] S. Salbany, Ultrafilter spaces and compactifications, *Portugal. Math.* 57 (2000), no. 4, 481–492.

Metric Dimension and Diameter in Bipartite Graphs

P. Dankelmann

University of Johannesburg
pdankelmann@uj.ac.za

E.J. Rivett-Carnac*

University of Johannesburg
emilyjcarnac@gmail.com

J.M. Morgan

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

SAMS Classification: 14 **Graph Theory and Combinatorics**

If every vertex of a graph G is determined by its distances to the vertices in a set $W \subseteq V(G)$, then W is known as a resolving set. The cardinality of a minimum resolving set is called the metric dimension of G. Chappell et al. [1] gave a sharp lower bound on metric dimension in terms of maximum degree; and Hernando et al. [2] proved a sharp upper bound on order in terms of metric dimension and diameter. In this talk we improve these bounds for bipartite graphs.

References:

[1] G.G. Chappell, J. Gimbel, and C. Hartman. Bounds on the metric and partition dimensions of a graph. *Ars Combinatoria* 88 (2008): 349-366.

[2] C. Hernando, M. Mora, I.M. Pelayo, C. Seara and D.R. Wood, Extremal graph theory for metric dimension and diameter, *Electron. J. Combin.* 17 (2010) 1-28.

Conditional Expectation and Mixing in Riesz Spaces

M.J. Rogans

University of the Witwatersrand
michael.rogans@wits.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

The study of stochastic processes in a measure-free setting has been facilitated in recent times through the abstraction of the underlying space of measurable functions as a Riesz space satisfying certain order properties. As an introduction to this growing field of research, this abstraction will be presented explicitly, after which the characterisation of conditional expectation operators in a Riesz space will be considered. Finally, the notion of mixing will be discussed, in which results from joint work with W.-C. Kuo and B.A. Watson in [1] will be presented.

References:

[1] W.-C. Kuo, M.J. Rogans, B.A. Watson, Mixing inequalities in Riesz spaces, *J. Math. Anal. Appl.*, **456** (2017), 992-1004

Unsteady MHD slip flow of a reactive Newtonian fluid in a channel filled with a porous medium

L. Rundora*

Department of Mathematics and Applied Mathematics,University of Limpopo
lazarus.rundora@ul.ac.za

N.H. Sekgothe

Department of Mathematics and Applied Mathematics,University of Limpopo
hazel.sekgothe@gmail.com

SAMS Classification: 16 **General Session**

This article presents an analysis of the combined effects of Navier slip, chemical reaction and radiation on unsteady MHD flow of a viscous incompressible, electrically conducting fluid through a vertical channel filled with a reactive porous medium. Constant heat and mass flux boundary conditions are assumed on the heated wall, and viscous and Joule dissipations are neglected in the energy equation. It is also assumed that a frst order chemical reaction occurs between the diffusing species and the fluid and that the fluid absorbs/emmits radiation. The semi-analytic Adomian decomposition method is employed to solve the dimensionless flow governing equations. A succinct analysis of the effects of the various embedded parameters on the thermo-mechanical system will be conducted.

Convexities in T_0-quasi-metric spaces and best approximations

H. Sabao

School of Mathematics, University of the Witwatersrand Johannesburg 2050 , South Africa
hope.sabao@wits.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

In this talk, we present convexities in T_0-quasi-metric spaces, namely; Menger convexity, Takahashi convexity, strong convexity and M-convexity. In the metric sense, these convexities rely on the concept of betweenness, a fundamental concept to axiomatic geometry. Therefore, we start by presenting betweenness in T_0-quasi-metric spaces. Thereafter, we present convexities in T_0-quasi-metric spaces and some best approximations for M-convex T_0-quasi-metric spaces.

References:

[1] L. M. Blumenthal, 1958. Theory and applications of distance geometry. Clarendon Press, Oxford.

[2] S. Cobzas, 2013. Functional Analysis in Asymmetric Normed Spaces. Birkhäuser, Basel.

[3] P. Fletcher, W.F. Lindgren, 1982. Quasi-Uniform Spaces. Dekker, New York.

[4] R. Khalil, 1988. Best approximation in metric spaces, *Proc. Amer. Math. Soc.* **103**, pp. 579–586.

[5] H.-P. A. Künzi, F. Yildiz, 2016. Convexity structures in T_0-quasi-metric spaces, *Topol. Appl* **200**, pp. 2–8.

Truncated Lévy Flights to Fight Crime

A. K. Schönfeldt

University of Cape Town
schabr004@myuct.ac.za

SAMS Classification: 17 **General Session**

This paper starts by reviewing the research done on modelling opportunistic crime in residential areas using statistical agent based models and the developments made in how criminal behaviour is modelled. It describes the development of code to run mean field simulations based on a model that uses truncated Lévy Flights [1] to model criminal mobility, and key results obtained from these simulations are compared those obtained in the original paper. Finally, the model is adapted to model the behaviour of individual criminals and direct stochastic simulations are carried out. This is done to illustrate, by using individual criminals as opposed to a theoretical distribution of criminals, the relationship between repeat victimisation and the development of predictable crime hot spots.

References:

[1] C. Pan, B. Li, C. Wang, Y. Zhang, N. Geldner, L. Wang and A. L. Bertozzi. Crime modelling with truncated lévy flights for residential burglary models. *Mathematical Models and Methods in Applied Sciences*, **28**:1857-1880, 2018.

Identities, approximate identities and topological divisors of zero in Banach algebras

F.P. Schulz*

University of Johannesburg
francoiss@uj.ac.za

R.M. Brits

University of Johannesburg
rbrits@uj.ac.za

M. Hasse

University of Johannesburg
Melanie.Hasse@standardbank.co.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

In [1] Bhatt and Dedania exposed certain classes of Banach algebras in which every element is a topological divisor of zero. In this talk we identify a new (large) class of Banach algebras with the aforementioned property, namely, the class of non-unital Banach algebras which admits either an approximate identity or approximate units. This also leads to improvements of results by Loy and Wichmann, respectively. If we observe that every single example that appears in [1] belongs to the class identified in the current talk, and, moreover, that many of them are classical examples of Banach algebras with this property, then it is tempting to conjecture that the classes exposed in [1] must be contained in the class that we identify here. However, we shall expose the (somewhat elusive) counterexamples. Furthermore, we shall investigate the role completeness plays in these results and show, by giving a suitable example, that the assumptions we make are not superfluous. The ideas considered here will also yield a pleasing characterization: The socle of a semisimple Banach algebra is infinite-dimensional if and only if every socle-element is a topological divisor of zero in the socle.

References:

[1] S.J. Bhatt, H.V. Dedania, Banach algebras in which every element is a topological divisor of zero, *Proc. Amer. Math. Soc.* 123 (1995) 735–737.

Topologies on modular quasi-pseudometric spaces

K. Sebogodi*

University of Johannesburg
ksebogodi@uj.ac.za

O. Olela Otafudu

University of the Witwatersrand
olivier.olelaotafudu@wits.ac.za

SAMS Classification: 05 **Categories, Algebra, Topology, and Logic**

The concept of modular metric on an arbitrary set generalising the classical notion of modulars over linear spaces was introduced in [1]. In this talk, we discuss modular metric which does not satisfy the symmetric axiom of a modular metric that we call modular quasi-pseudometric. Furthermore, we point out topologies on a set equipped with modular quasi-pseudometric. It turns out that a set equipped with a modular quasi-pseudometric is a bitopological space in the sense of Kelly.

References:

[1] V.V. Chistyakov, Modular metric spaces, I: Basic concepts, *Non-linear Anal.* 72 (2010), 1-14.

On the dynamics of tropical cyclones

M.M Sedjro

African Institute for Mathematical Sciences
sedjro@aims.ac.az

SAMS Classification: 11

Lie Symmetries and Nonlinear DEs

Almost axisymmetric flows are designed to model tropical cyclones. In 1988, Shutts et al proposed a discrete procedure to construct a solution to the forced axisymmetric flows within a rigid boundary. In this talk, I will discuss how we have extended their results to the continuous case within an appropriate free boundary domain. In addition, I will explain how overcoming an elliptic regularity issue could be an important step toward extending our procedure to handle almost axisymmetric flows.

Solving nonlinear differential equations using Adomian decomposition method.

N.H. Sekgothe*

Department of Mathematics and Applied Mathematics,University of Limpopo
hazel.sekgothe@ul.ac.za

L. Rundora

Department of Mathematics and Applied Mathematics,University of Limpopo
lazarus.rundora@ul.ac.za

SAMS Classification: 16 **General Session**

Modelling with differential equations is of paramount importance as it provides pertinent insight into the dynamics of many engineering and technological devices and/or processes. Many such models, however, involve differential equations that are inherently nonlinear and difficult to solve. In this work, we investigate the use of Adomian decomposition method (ADM) in solving nonlinear ordinary and partial differential equations. The efficiency of this method will be investigated.

Chaotic dynamics in disordered nonlinear lattices: Symplectic Integrators and the thermodynamic limit

B. Senyange* and Ch. Skokos

Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa.
snybob001@myuct.ac.za

SAMS Classification: 12 **General Session**

We implement several symplectic integrators, which are based on two part splitting method, for studying the chaotic behavior of one-and two-dimensional disordered lattices with many degrees of freedom and investigate their numerical performance. We consider many different initial energy excitations and follow the evolution of the created wave packets in the various dynamical regimes exhibited by these models. We compare the effciency of the considered integrators by checking their ability to correctly reproduce several features of the wave packets propagation, like the characteristics of the created energy distribution and the time evolution of the systems' maximum Lyapunov exponent estimator. Among the tested integrators the fourth order $ABA864$ scheme [1, 2] and the sixth order scheme $s11ABA82\_6$ [3] showed the best performance as they needed the least CPU time for capturing the correct dynamical behavior of all considered cases when a moderate and a high accuracy in conserving the systems' total energy value was required respectively. We then use the most efficient integrators to study the thermalization problem for the one-dimensional, disordered nonlinear lattices in the thermodynamic limit [4].

References:

[1] S. Blanes, F. Casas, A. Farrés, J. Laskar, J. Makazaga, A. Murua, New families of symplectic splitting methods for numerical integration in dynamical astronomy, *App. Num Math*, **68**, 58–72 (2013).

[2] A. Farrés, J. Laskar, S. Blanes, F. Casas, J. Makazaga, A. Murua, High precision symplectic integrators for the SolarSystem, *Cel. Mech. Dyn. Astr.* **116**, 141–174 (2013).

[3] B. Senyange, Ch. Skokos, Computational efficiency of symplectic integration schemes: application to multidimensional disordered KleinGordon lattices, *Eur. Phys. J. Special Topics* **227**, 625–643 (2018).

[4] W. Fu, Y. Zhang, H. Zhao, Universal law of thermalization for one-dimensional perturbed Toda lattices, *New J. Phys.* **21**, 043009 (2019).

Weighted commutators as the Huq commutator in points

V.T. Shaumbwa

Stellenbosch University
shaumbwa@sun.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

We investigated the notion of weighted commutators, which is known to capture classical commutators as special examples. We will show how weighted commutators can be expressed in terms of another commutator called the Huq commutator, and in addition, show that various facts about commutators follow from this general fact.

A characterization of subcubic graphs with smallest possible matching number

M.A. Henning

University of Johannesburg
mahenning@uj.ac.za

Z.B. Shozi*

University of Johannesburg
zekhaya@aims.ac.za

SAMS Classification: 14 **Graph Theory and Combinatorics**

In this paper, we study tight lower bounds on the matching number $\alpha'(G)$ of subcubic graphs G, that is, graphs with maximum degree at most three. In 2017 Haxwell and Scott [1] proved that if G is a connected subcubic graph, then $\alpha'(G) \geq \frac{4}{9}n_3(G) + \frac{3}{9}n_2(G) + \frac{2}{9}n_1(G) - \frac{1}{9}$, where $n_i(G)$ denotes the number of vertices of degree i in G. In this paper we characterize the graphs achieving equality in the lower bound on the matching number given by Haxwell and Scott.

References:

[1] P. E. Haxell and A. D. Scott, On lower bounds for the matching number of subcubic graphs. *J. Graph Theory* **85**(2) (2017), 336–348.

Arrhenius activation energy in unsteady Casson nanofluid flow over a stretching sheet with nonlinear thermal radiation and binary chemical reaction

H.M. Sithole Mthethwa*, I.S. Oyelakin, P.K. Kameswaran, S. Shaw

University of KwaZulu Natal
sitholeh@ukzn.ac.za

SAMS Classification: 13

General Session

This study presents analysis of Arrhenious activation energy and binary chemical reaction in a Casson nanofluid flow. The thermal radiation is assumed to be nonlinear and as such, the binary chemical reaction rate is taken as a function of temperature. The chemical reaction effects are studied using the binary chemical reaction with Arrhenius energy. The study includes the significance of entropy generation in an unsteady boundary layer flow and heat transfer. The solution to the transformed coupled system of nonlinear partial differential equations are obtained using the bivariate spectral quasi-linearisation method. Numerical results pertaining to velocity, temperature, concentration, entropy generation and Bejan number are discussed graphically.

Umbilic null hypersurfaces in indefinite Kaehler manifolds and their geometric interpretation

S. Ssekajja

University of the Witwatersrand
samuel.ssekajja@wits.ac.za

SAMS Classification: 04 **Categories, Algebra, Topology, and Logic**

Any null hypersurface, (M, g), of an indefinite Kaehler manifold, $(\overline{M}, \overline{J}, \overline{g})$, is endowed with two special null vector fields $U := -\overline{J}N$ and $V := -\overline{J}\xi$, both belonging to its screen distribution, where N and ξ, respectively, spans the transversal and normal bundle (radical distribution) to M. In this paper, we define the U and V-null sectional curvatures and then apply them to totally umbilic null hypersurfaces. In particular, we prove that the squares of the umbilicity factors measures, up to third order, the differences in lengths of any two spacelike geodesics tangent to the $\overline{J}$-invariant distribution D_0 over M.

References:

[1] K. L. Duggal and A. Bejancu, Lightlike submanifolds of semi-Riemannian manifolds and applications, Kluwer Academic Publishers, 1996.

[2] K. L. Duggal and B. Sahin, Differential geometry of lightlike submanifolds. Frontiers in Mathematics, Birkhäuser Verlag, Basel, 2010.

Köthe duality of weighted non-commutative Orlicz spaces

C. Steyn*

North-West University
29576393@nwu.ac.za

L.E. Labuschagne

North-West University
Louis.Labuschagne@nwu.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Motivated by considerations in statistical quantum mechanics, L. Labuschagne and A. Majewski introduced the concept of weighted non-commutative Banach function spaces. Given a semi-finite von Neumann algebra equipped with a sfn trace τ it is by now well known how one can construct non-commutative Banach function spaces. The weight comes in the form of an element $x \in L^1(\widetilde{\mathcal{M}}) + \mathcal{M}$. One then defines a pseudo trace using x as the map $\tau_x : \widetilde{\mathcal{M}} \mapsto [0, \infty] : a \mapsto \int \mu_t(a)\mu_t(x)dt$.

In the aforementioned physical motivation, weighted non-commutative Orlicz spaces were of particular interest. First we will show two equivalent constructions of weighted non-commutative Orlicz spaces. The main purpose of the talk will be to discuss Köthe duality of these spaces.

H-selfadjoint square roots of H-nonnegative matrices

D.B. Janse van Rensburg

North-West University
dawie.jansevanrensburg@nwu.ac.za

M. van Straaten*

North-West University
madelein.vanstraaten@nwu.ac.za

F. Theron

North-West University
frieda.theron@nwu.ac.za

C. Trunk

Technical University Ilmenau
carsten.trunk@tu-ilmenau.de

SAMS Classification: 09 **Functional Analysis and Operator Theory**

An indefinite inner product is a function $[\cdot\,,\cdot]$ from $\mathbb{C}^n \times \mathbb{C}^n$ to $\mathbb{C}^n$ which is linear in the first argument, anti-symmetric, and nondegenerate, i.e. if $[x, y] = 0$ for all $y \in \mathbb{C}^n$, then $x = 0$. There is a unique invertible Hermitian matrix H corresponding to each indefinite inner product in the sense that $[x, y] = \langle Hx, y\rangle$, where $\langle \cdot\,, \cdot \rangle$ represents the usual Euclidean inner product in $\mathbb{C}^n$. An $n \times n$ complex matrix B is called H-selfadjoint if $[Bx, y] = [x, By]$ for all x, y in $\mathbb{C}^n$, and H-nonnegative if $[Bx, x] \geq 0$ for all x in $\mathbb{C}^n$. We find necessary and sufficient conditions for the existence of an H-selfadjoint square root of B. We also find the general form of these square roots.

On subrings of f-rings induced by ideals

B. Tlharesakgosi

University of South Africa
tlharb@unisa.ac.za

SAMS Classification: 02 **Categories, Algebra, Topology, and Logic**

An ideal I of a ring A is a *z-ideal* if whenever two elements of A are in the same set of maximal ideals and I contains one of the elements, then it also contains the other. An ideal I of A is a *d-ideal* if whenever two elements are equally annihilated and I contains one of the elements, then it also contains the other. Let L be a completely regular frame and let $\mathcal{R}L$ be the ring of real-valued continuous functions on L. Let I be an ideal of $\mathcal{R}L$ and consider the subring of the form $I + \mathbb{R}$ of $\mathcal{R}L$.

In this talk, we characterize z-ideals and d-ideals of $I+\mathbb{R}$. We shall also characterize *P-ideals* I (every prime ideal of I is maximal, when I is viewed as a ring in its own right) for which the rings $I + \mathbb{R}$ are von Neumann regular.

Stagnation Point Flow of Magneto-Nanofluid Towards a Convectively Heated Stretching or Shrinking Sheet with Navier Slip

K.S. Tshivhi*

Faculty of Military Science, Stellenbosch University, Private Bag X2, Saldanha 7395, South Africa.
khodani.tshivhi@gmail.com

O. D. Makinde

Faculty of Military Science, Stellenbosch University, Private Bag X2, Saldanha 7395, South Africa.
makinded@gmail.com

SAMS Classification: 17 **Lie Symmetries and Nonlinear DEs**

Stagnation point flow is closely associated with surface cooling of engineering and industrial systems. It is a point where the local velocity of the coolant is brought to rest by the surface. Recently, the advancement in nanotechnology has provides a better ultrahigh-performance coolant known as nanofluid for many industrial technologies. This paper investigates the combined effects of magnetic field and Navier slip on stagnation flow of a conducting water base nanofluid towards a convectively heated stretching or shrinking sheet. The governing partial differential equations are transformed to nonlinear ordinary differential equations by using the suitable similarity transformations and solved numerically by using shooting method with Runge-Kutta-Fehlberg integration scheme. The behaviours of velocity, temperature, streamlines patterns, local skin friction, local Nusselt number and volume fraction of nanoparticles are discussed physically against various governing parameters via numerous explained graphical displays.

References:

[1] O. D. Makinde, Z.H. Khan, R. Ahmad, W. A. Khan. Numerical study of unsteady hydromagnetic radiating fluid flow past a slippery stretching sheet embedded in a porous medium. *Physics of Fluids*, 30, 083601 (7pages), 2018.

[2] O.D. Makinde, F. Mabood, M.S. Ibrahim. Chemically reacting on MHD boundary layer flow of nanofluid over a non-linear stretching sheet with heat source/sink and thermal radiation. *Thermal Science*, 22(1B) 495–506, 2018.

[3] O.D. Makinde, W.A. Khan, Z.H. Khan, Stagnation point flow of MHD chemically reacting nanofluid over a stretching convective surface with slip and radiative heat. *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering*. Vol. 231(4), 695, 2017.

[4] O.D. Makinde, W.A. Khan, J.R. Culham: MHD variable viscosity reacting flow over a convectively heated plate in a porous medium with thermophoresis and radiative heat transfer. *International Journal of Heat and Mass Transfer*, Vol.93, 595, 2016.

[5] O. D. Makinde, W. A. Khan, Z. H. Khan: Buoyancy effects on MHD stagnation point flow and heat transfer of a nanofluid past a convectively heated stretching/shrinking sheet. *International Journal of Heat and Mass Transfer* 62, 526–533, 2013.

[6] O. D. Makinde: Computational modelling of nanofluids flow over a convectively heated unsteady stretching sheet. *Current Nanoscience*, Vol.9, 673–678, 2013.

On the probability that a random subtree is spanning

S. Wagner

Stellenbosch University
swagner@sun.ac.za

SAMS Classification: 14

Graph Theory and Combinatorics

We consider the quantity $P(G)$ associated with a graph G that is defined as the probability that a randomly chosen subtree of G is spanning. Motivated by conjectures due to Chin, Gordon, MacPhee and Vincent on the behaviour of this graph invariant depending on the edge density, we establish first that $P(G)$ is bounded below by a positive constant provided that the minimum degree is bounded below by a linear function in the number of vertices. Thereafter, the focus is shifted to the classical Erdős-Rényi random graph model $G(n, p)$. It is shown that $P(G)$ converges in probability to $e^{-1/(ep_\infty)}$ if $p \to p_\infty > 0$ and to 0 if $p \to 0$.

The Dedekind completion of $C(K)$ and its order dual

J.H. van der Walt

University of Pretoria
janharm.vanderwalt@up.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Let K be a compact Hausdorff space, and $C(K)$ the vector lattice of continuous real valued functions on K. As is well known, the dual of $C(K)$ can be described in terms of regular Borel measures on K. It is also well known that $C(K)$ is, in general, not Dedekind complete. Several characterisations for its Dedekind completion, $C(K)^\delta$, are known, but there does not seem to be a characterisation for the dual of $C(K)^\delta$. In this talk, we give such a characterisation of the dual of $C(K)^\delta$ in terms of finitely additive measures on the category algebra of K.

A short survey on applications of formal power series algebras to topological algebras

M. Weigt*

Nelson Mandela University
Martin.Weigt@mandela.ac.za

I. Zarakas

gzarak@hotmail.gr

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Formal power series algebras have been used extensively in proving some deep results on Banach algebras. As an example, we mention the commutative Singer-Wermer conjecture proved by M.P. Thomas in 1988: The range of every derivation of a commutative Banach algebra is contained in the Jacobson radical of the Banach algebra.

In this talk, we give an overview of known results on the following two problems.

(i) Given a (generally) non-normed topological algebra $A[\tau]$ and $x \in A$, when is there a monomorphism $\theta : A \to \mathcal{F}$ with $\theta(x) = X$, where $\mathcal{F}$ is the algebra of all formal power series over A with indeterminate X?

(ii) Given a (generally) non-normed topological algebra $A[\tau]$ and $x \in A$, when is there a monomorphism $\psi : C[[X]] \to A$ with $\psi(X) = x$, where $C[[X]]$ denotes the algebra of all formal power series over the complex field C?

We also give a few minor observations here and there which do not appear to stand out in the current literature. This work was partially motivated with having in mind possible applications to unbounded derivations of generalized B*-algebras.

Global boundedness and stabilization in a two-competing-species chemotaxis-fluid system with two chemicals

R. Willie*

School of Mathematics, Statistics and Computer Science
University of KwaZulu-Natal. Westville Campus
4000 Durban. South Africa.
willier@ukzn.ac.za

P. Zheng

Chongqing University of Post and Telecommunications
Chongqing 400065. P.R. China.
zhengpan52@sina.com

C. Mu

College of Mathematics and Statistics
Chongqing University. Chongqing 401331
P.R. China. clmu2005@163.com

SAMS Classification: 11,13,17 **Functional Analysis and Operator Theory**

In this talk, we discuss global boundedness and stabilization to the following two-competing-species chemotaxis-fluid system with two chemicals;

$$\begin{cases} (n_1)_t + \mathbf{u}\cdot\nabla n_1 &= d_1\Delta n_1 - \chi_1\nabla\cdot(n_1\nabla c) + \mu_1 n_1(1-n_1-a_1 n_2) \\ c_t + \mathbf{u}\cdot\nabla c &= d_2\Delta c - \alpha_1 c n_2 \\ (n_2)_t + \mathbf{u}\cdot\nabla n_2 &= d_3\Delta n_2 - \chi_2\nabla\cdot(n_2\nabla v) + \mu_2 n_2(1-n_2-a_2 n_1) \\ v_t + \mathbf{u}\cdot\nabla v &= d_4\nabla v - \alpha_2 v n_1 \\ \mathbf{u}_t + \kappa(\mathbf{u}\cdot\nabla)\mathbf{u} &= \Delta u + \nabla P + (\beta_1 n_1 + \beta_2 n_2)\nabla\phi \\ \nabla\cdot\mathbf{u} = 0 & \end{cases}$$

in $\Omega\times(0,\infty)$ where $\Omega\subset IR^N, N=2,3$ is a smooth bounded domain. The system is subject to Neumann homogeneous boundary conditions for n_1, n_2, c, v and zero Dirichlet boundary conditions for $\mathbf{u}$, $\kappa\in\{0,1\}$, positive parameters $d_i, \chi_j, \mu_j, a_j, \alpha_j, \beta_j$ for $i=1,2,3,4$, $j=1,2$, and positive initial data, $n_1^0, n_2^0, c_0, v_0, \mathbf{u}_0$. Using the standard heat-semigroup argument, we prove in $N=2$, and $\kappa=1$ that the system with smooth initial data admits a unique globally defined bounded solution. Secondly, using the maximal Sobolev regularity and the semigroup method we

prove in $N = 3$, $\kappa = 0$ that the model possesses a unique globally defined classical solution provided there exists a $\theta_0 > 0$ such that $\frac{\max\{\chi_1,\chi_2\}}{\min\{\mu_1,\mu_2\}} < \theta_0$. Lastly, by means of energy functionals and comparison method, we prove that the globally bounded solution of the system converges to different constant steady states solutions, accordingly to varied values of $a_j, j = 1, 2$. Precise convergence rates of the global solutions to the constant steady states are furnished.

Isometric isomorphisms between certain Banach spaces

M. Wortel

University of Pretoria
marten.wortel@up.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

Let K and L be compact Hausdorff spaces. Motivated by problems in Hilbert's metric geometry and maximal deviation preserving maps, we prove a characterisation of isometric isomorphisms from $C(K)$ modulo the constant functions into $C(L)$ modulo the constant functions. The proof is based on similar ideas as the proof of the Banach-Stone Theorem. We then consider the same problem with $C(K)$ and $C(L)$ replaced by arbitrary unital C^*-algebras, and we present a solution of this considerably more difficult problem.

This is joint work with Mark Roelands and Bas Lemmens from the University of Kent (UK).

On the maximum F-dimension of a Lie solvable index 2 subalgebra of the $n \times n$ matrix algebra $M_n(F)$ over a field F

L. van Wyk*

Stellenbosch University
LvW@sun.ac.za

M. Ziembowski

Warsaw University of Technology
m.ziembowski@mini.pw.edu.pl

SAMS Classification: 02

General Session

We study, amongst others, the question of whether, for a field F, a Lie solvable index 2 subalgebra of $M_n(F)$, for some n, with F-dimension larger than the maximum dimension $2 + \left\lfloor \frac{3n^2}{8} \right\rfloor$ of a subalgebra of $M_n(F)$ satisfying the polynomial identity $[x_1, y_1][x_2, y_2] = 0$, exists.

Controllability and observability of poset causal systems

J. Zeelie*

North-West University
24698245@nwu.ac.za

S. Ter Horst

North-West University
Sanne.TerHorst@nwu.ac.za

SAMS Classification: 09, 17 **Functional Analysis and Operator Theory**

In classical control systems, minimal realizations are obtained by applying the Kalman decomposition. This isolates the part of the system that is both controllable and observable. Poset causal systems, introduced in [1], are decentralized systems with a specific communication structure between its subsystems. This communication structure is realized as a specific zero structure of the system matrices. Applying the classical Kalman decomposition to these matrices, destroys their zero structure. The question arises whether one can define concepts of controllability and observability which respects structure. We define upstream controllability and downstream observability. For a given poset causal system, we define its dual system. It is shown that upstream controllability of a system and downstream observability of its dual system are dual concepts.

References:

[1] Shah, P. A partial order approach to decentralized control. PhD Thesis, Massachusetts Institute of Technology. 2011.

Dependence of eigenvalues of fourth order boundary value problems with transmission conditions

B. Zinsou

University of the Witwatersrand
bertin.zinsou@wits.ac.za

SAMS Classification: 09 **Functional Analysis and Operator Theory**

A general fourth-order regular ordinary differential equation with eigenvalue dependent boundary conditions and transmission conditions are considered. We prove that the eigenvalues depend continuously and smoothly on the coefficients of the differential equation and on the boundary and transmission matrices. We provide as well formulas for the derivatives with respect to each of these parameters.

References:

[1] B. Zinsou: Dependence of eigenvalues of fourth order boundary value problems with transmission conditions, *Rocky Mountain J. Math.* (to appear).

Measure approximation for Wasserstein-perturbed expected values

A.J. van Zyl

Department of Mathematics and Applied Mathematics, University of Pretoria
gusti.vanzyl@up.ac.za

SAMS Classification: 09,10 **Functional Analysis and Operator Theory**

We consider the minimization problem

$$\inf\left\{\int_X V(x)\ d\mu(x) : W_1(\mu,\mu_0) \leq \theta\right\},$$

with W_1 denoting the 1-Wasserstein distance between probability measures on a Polish space. We discuss conditions on a sequence $(\mathcal{F}_n)$ of σ-algebras, as well as on V and on X, that ensure the convergence of the minima of the $\mathcal{F}_n-$restricted minimization problems to the minimum of the initial problem.

Plenary speakers

Professor Garth Dales

Lancaster University, Lancaster, United Kingdom

H. G. Dales is currently a semi-retired, part-time professor of Pure Mathematics at the University of Lancaster, UK. He began his mathematical career with an Open Scholarship to Queens' College, Cambridge, in 1963, and he obtained a PhD under the supervision of Dr G. R. Allan in 1970. After three years at the University of Glasgow in Scotland, he became a lecturer, and eventually a professor and Head of Department, at the University of Leeds, retiring in 2012. During those years he spent several periods at the University of California at Berkeley and Los Angeles, mainly working with Professors William Bade and Phil Curtis. Dales is the author of about 100 research publications, including several books. The main one is *Banach algebras and automatic continuity*, published by OUP as a London Mathematical Society Monograph; there are also two books on mathematical logic with W. H. Woodin. He also has a joint book with Dr Dona Strauss, who obtained a degree from the University of Cape Town in 1954. At present he is working on a final memoir, *Banach function algebras, Arens regularity, and BSE norms*, jointly with A. Ülger of Istanbul. He has had about 20 PhD students. Dales has been a member of the Council of the London Mathematical Society and was Vice-Chairman of the Ethics Committee of the European Mathematical Society from 2011 to 2017. In November 2019, Dales will will be visiting Professor Jan Harm van der Walt in Pretoria and Professor Sonja Mouton in Stellenbosch.

Professor Eunice Mphako-Banda

University of the Witwatersrand, Johannesburg, South Africa

Eunice Gogo Mphako-Banda was born in Blantyre, Malawi. She graduated from the University of Malawi with a B.Ed. in sciences in 1992. This was followed by a Postgraduate Diploma in Mathematics from the University of Sheffield, UK, in 1994, MSc in Mathematics from the University of Manchester, UK, in 1995 and PhD in Discrete Mathematics from Victoria University of Wellington, New Zealand in 2001. She was a recipient of the UNIMA Scholarship for girls in sciences from 1988–1991, the British Council Scholarship in 1994 and 1995 and the New Zealand Overseas Development Scholarship in 1998. Her academic career started at the Department of Mathematical Sciences, University of Malawi in 1993 as Associate Lecturer where she eventually rose to the rank of Senior Lecturer and in 2003 became the Head of School. She joined the University of KwaZulu-Natal, School of Mathematical Sciences in 2007 as a Lecturer. In September 2008, she joined the University of the Witwatersrand, School of Mathematics as a Lecturer, became a Senior Lecturer in December 2011, Associate Professor in December 2013 and Professor in March 2019. Her current research interests include Matroid Theory, Low-Dimension Topology-Knot Theory, Combinatorics and Graph Theory. Her research in Matroid Theory is focused on matroid construction and polynomials. In Knot Theory, her interest vary from knot invariants to knot construction. She uses Combinatorics and Graph Theory as tools to solving problems in Matroid Theory and Knot Theory.

Professor Aleš Pultr

Charles University, Prague, Czech Republic

Aleš Pultr (1938), married, 2 children. Professor of Charles University in Prague, fellow of the Czech Learned Society. (Co)author of 6 books and 3 chapters in books. Main interests: (Point-free) topology, category theory and structure theory, also combinatorics. Frequent visits in South Africa, collaboration with South African mathematicians.

Professor Daya Reddy

University of Cape Town, Cape Town, South Africa

Daya Reddy completed a bachelor's degree in civil engineering at the University of Cape Town, a Ph.D. degree at Cambridge University in the UK, and a post-doctoral year at University College London. He currently holds the South African Research Chair in Computational Mechanics, in the Department of Mathematics and Applied Mathematics at the University of Cape Town. He served as Dean of the Faculty of Science at UCT between 1999 and 2005. His teaching and research activities reflect his multidisciplinary perspectives, which he pursues largely through the Centre for Research in Computational and Applied Mechanics (CERECAM), a centre comprising academic staff and postgraduate students in five different departments. Much of his work is concerned with mathematical and numerical analysis of problems arising in solid and fluid mechanics. His many publications include two graduate-level texts, and a research monograph, now in its second edition, on plasticity theory. Daya Reddy is actively involved in bodies that work towards strengthening the scientific enterprise and providing science advice to policymakers. He served a term as President of the Academy of Science of South Africa, and is currently President of the International Science Council, the largest representative non-governmental scientific organization globally. He is a recipient of the Award for Distinguished Service from the South African Association for Computational and Applied Mechanics,the SAMS Award for Research Distinction, and the Order of Mapungubwe from the President of South Africa. He has held numerous visiting positions, including those of Visiting Faculty Fellow at the University of Texas at Austin and the Timoshenko Lecturer at Stanford University. He is a recipient of the Georg Forster Research Award from the Alexander von Humboldt Foundation of Germany.

Professor Hamsa Venkatakrishnan

University of the Witwatersrand, Jonannesburg, South Africa

Professor Hamsa Venkat holds the SARChI SA Numeracy Chair at the University of the Witwatersrand in Johannesburg — now in its second 5-year phase of research and development in primary mathematics. She leads a team of academics, postdoctoral and postgraduate students, all involved in studying and improving primary mathematics teaching and learning in government primary schools serving disadvantaged students. Prior to this, Hamsa was based in England, working initially as a high school mathematics teacher in London comprehensive schools, before moving into teacher education at the Institute of Education and research in mathematics education at Kings College London. She obtained her PhD at Kings College London and is the winner of the 2005 British Educational Research Association dissertation award for making the most significant doctoral contribution to research in education in 2004. She has published widely, across articles and books, guest edited a range of Special Issues, and her research work continues to feed into provincial and national policy initiatives.

Useful Information

Getting to UCT

SAMS2019 will be held on UCT's **Upper Campus** in Rondebosch, which is easily accessible from the **Woolsack Drive/University of Cape Town** exit on the **M3** (if approaching from the South, take the **UCT** exit). Detailed directions to campus can be found here.

Venues for presentations

Conference talks will be held in the following venues, located on Upper Campus at the South end of University Avenue (see **map**, p177).

- New Lecture Theatre (all plenary talks).
- LS1A, LS1B, LS1C, LS1D, LS1E (Leslie Social Sciences Building).

All venues have data projectors and blackboards.

Coffee breaks and lunches

Coffee breaks and lunches will be held in the foyer of the New Lecture Theatre, located on Upper Campus at the South end of University Avenue (see **map**, p177). There will be buffet lunches on Monday and Tuesday and a packed lunch on Wednesday.

Congress dinner

The Congress Dinner will be held at 1900 on Tuesday 3 December at Simon's in Groot Constantia, the oldest wine-producing farm in South Africa. Groot Constantia is about twenty minutes drive from UCT. If you have booked for the Congress Dinner, you will receive a dinner voucher in your name when you register. A bus will be provided from the New Lecture Theatre to the Congress Dinner, leaving at 1830. **If you wish to take the bus to the Congress Dinner, you must sign up at the Registration Desk by 1530 Monday 2 December**.

ATMs

There are ABSA, Capitec, FNB, Nedbank, and Standard Bank ATMs on Upper Campus (see **map**, p177). There are also ATMs in the center of Rondebosch.

Wifi access

Wifi is complimentary on the UCT campus for all SAMS2019 delegates. Each delegate will receive a slip containing their login details with their name badge.

There will be a technician onsite on Monday 2 December 0800–1030 to assist any delegates who have wifi issues.

UCT is part of the `eduroam` network. If your home institution is an `eduroam` member, your home institution login credentials should work on UCT's wifi network.

Registration Desk

The Registration Desk is situated in the foyer of the New Lecture Theatre and is open during the following times:

Sunday 1 December	1700 to 1800
Monday 2 December	0800 to 1530
Tuesday 3 December	0800 to 1530
Wednesday 4 December	0800 to 1300

Department of Mathematics and Applied Mathematics

UCT's Department of Mathematics and Applied Mathematics is located in the Mathematics Building on the Northeast corner of Jameson Plaza, about five minutes walk up University Avenue from the New Lecture Theatre.

Parking

SAMS2019 participants may park in student bays (the ones with no coloured rectangle or triangle) in lots **P5** and **P17** (see **map**, p177), both of which are close to the New Lecture Theatre. You do *not* have to get a Visitor's Parking Disc.

Please do not park in other parking lots or in red or yellow bays. UCT's campus is patrolled by Traffic Officers. If you park somewhere you're not supposed to, you will almost certainly receive a fine (or even have your wheel clamped).

Jammie Shuttle

UCT has a fleet of 26 buses, called Jammie Shuttles, that operate on fixed routes around campus, to student residences, and to some railway stations. **SAMS2019 delegates may use their conference name badge to travel on the Jammie Shuttles (there is no charge)**. For more information, consult the Jammie Shuttle Route Maps and Timetables page.

Some shops and restaurants close to UCT

A number of food outlets on UCT's Upper Campus will be open during SAMS2019. Main Road in the center of Rondebosch, about five minutes drive from Upper Campus, has a number of shops, fast food places, and restaurants. Here is an incomplete list of what's in the center of Rondebosch. Delegates wanting more information should Google or ask at the Registration desk.

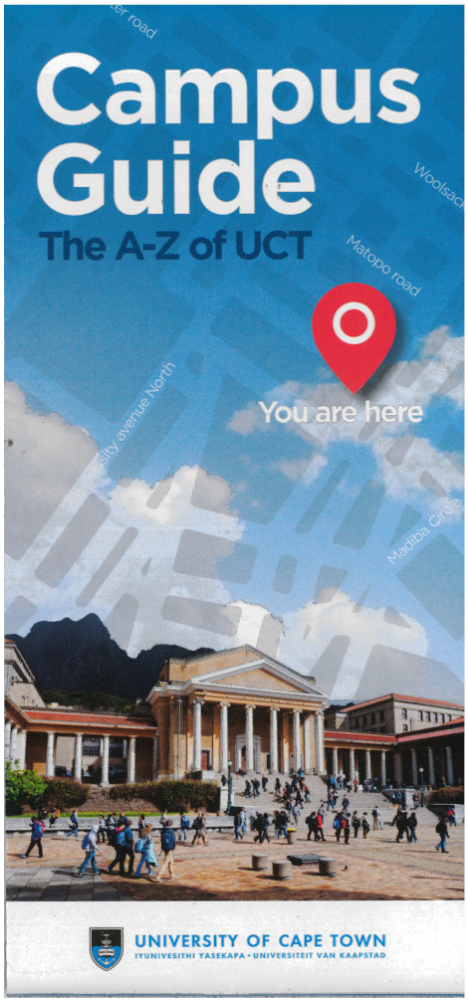
Shops	**Fast food and restaurants**
Checkers	Baxter Theatre Restaurant
Clicks	Cocoa Wah-Wah
Pick n Pay	Hussar Grill
Van Schaik Bookstore	McDonalds
Woolworths Food	Nando's
Rustenburg Pharmacy	KFC
PostNet	Steers
	Kauai
	Debonairs Pizza
	Prashad Café
	Pizza Hut
	St Elmo's Pizza
	Maharajah Eatery
	Vida e Caffé

Safety information and emergency contact numbers

UCT's campus is open to the public. The campus is patrolled by Campus Protection Services (CPS), who can be contacted 24 hours a day on the numbers below. While the rate of crime on and around campus is low, participants in SAMS2019 should be aware of their surroundings and not leave belongings unprotected. After hours, we suggest that participants who are on foot travel in groups and use the Jammie Shuttles for better safety.

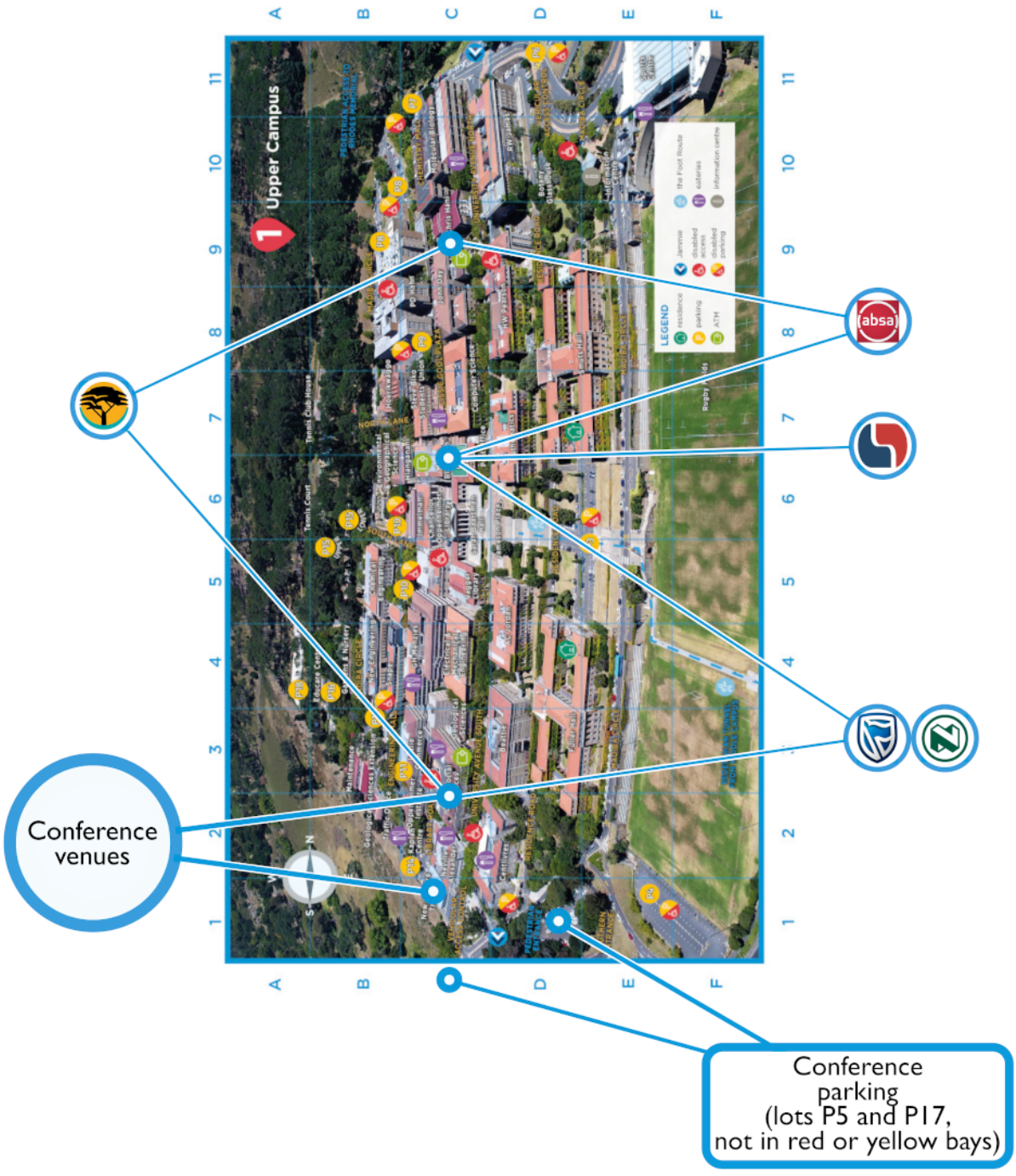
UCT Campus Protection Services (CPS) 24-hour Hotline	021 650 2222/3 080 650 2222 (toll free)
UCT Sexual Assault 24-hour Hotline	072 393 7824
South African Police Service (Flying Squad)	10111 (from a landline) 112 (from a cellphone)
South African Police Service (Rondebosch)	021 685 2476 021 685 7345
South African Police Service (Cape Town Central)	021 467 8000/1/2
Rape Crisis	021 447 9762
Ambulance	10177
Mountain Rescue	021 948 9900
Sea Rescue	021 449 3500
UCT Department of Mathematics and Applied Mathematics	021 650 3191

UCT Campus Guide



Each SAMS2019 participant will receive a copy of the *UCT Campus Guide*, which includes a detailed map of campus. **The map on the following page** shows some additional information about important locations for SAMS2019.

Map of SAMS2019 venues, parking, and Upper Campus ATMs



About SAMS2019

The 62nd Annual Congress of the South African Mathematical Society is hosted by the Department of Mathematics and Applied Mathematics at the University of Cape Town and organized by UCT's Conference Management Center. Financial support was provided by the DSI-NRF Center of Excellence in Mathematical and Statistical Sciences (CoE-MaSS) and by the South African Mathematical Society.

Local Organizing Committee

Prof Haris Skokos (Conference Chair)
Prof Peter Dunsby
Dr Francois Ebobisse Bille
Dr David Erwin
Dr Tamar Janelidze-Gray
Dr Julien Larena
Dr Juana Sanchez-Ortega
Dr Jonathan Shock