

# Title and Abstract for Talks at Alberta Mathematics Dialogue 2016

Mount Royal University

April 28-29, 2016

## 1 Invited Plenary Talks

1. **Richard Guy**, University of Calgary

Title: The Leaning Tower of Pingala

Abstract: Starting with zero and one, we can generate a sequence of polynomials whose coefficients form a leaning tower, usually associated with Pascal, though going back to Pingala, more than two thousand years ago. The polynomials give us an infinity of divisibility sequences, including the natural numbers, the Mersenne numbers, the Fibonacci numbers, the Brahmagupta-Pell numbers (which we believe were known to the Babylonians four thousand years ago), the Jacobsthal numbers, and the Chebyshev polynomials.

2. **Terry Gannon**, University of Alberta

Title: Moonshine: Old and New

Abstract: Almost 40 years ago John McKay noticed that  $196884 = 196883 + 1$ , and Monstrous Moonshine was born. In 1998 Borcherds won a Fields Medal primarily for his work explaining McKay's equation. Five years ago string theorists Eguchi, Ooguri and Tachikawa observed that  $90 = 45 + 45$ ,  $462 = 231 + 231$  and  $1540 = 770 + 770$ , and Mathieu Moonshine was born. These new equations have still not been explained. My talk will introduce you to these two moonshines.

3. **Anatoliy Swishchuk**, University of Calgary

Title: What is Financial Mathematics?

Abstract: This talk is devoted to the history of financial mathematics, description of basic ideas, methods and some remarkable results, association it with financial industry, and emerged new directions.

4. **Vaclav Zizler**, University of Alberta

Title: The Prague School of Analysis from B. Bolzano to D. Preiss

Abstract: We review some results obtained at the Prague School in differentiation in Banach spaces, ranging from the Bolzano's example of everywhere continuous nowhere differentiable function, through the Kurzweil-Whitfield result on differentiable bump functions on the space of the continuous functions, to Preiss result on differentiation of Lipschitz functions on Hilbert spaces. We finish with the result on the smooth variational principle. Some personal memories of the speaker will be included as well.

## 2 Teaching & Pedagogy

Session Chairs:

1. Geri Lorway  
Presenting on behalf of ARPDC and the EMPLO development team, level one.  
Title: EMPLO: A Collaborative Project for Supporting the Instructional Expertise of Elementary Teachers in Alberta  
Abstract: This talk will introduce participants to the work and website that is emerging from the Elementary Mathematics Professional Learning Opportunities Project. The goals, strategic plan and materials that are available to date will be shared as participants are introduced to the emerging website and offered a channel by which they can offer their suggestions and insights around suitable topics, articles, problems and insights from research on the teaching and learning of ELEMENTARY mathematics.
2. Claude Laflamme  
University of Calgary  
Title: Lyryx with Open Texts a sustainable model for OER  
Abstract: Open Educational Resources (OER) provide both free and adaptable content, and have the potential to replace most of our current high cost and quality material from the big publishers. But who will adapt the material, prepare whatever else may be needed to run a course, and support students and instructors?  
  
I will present “Lyryx with Open Texts (LOTS)”, a sustainable business model aimed at developing and supporting OER, in particular offering support and editorial services to instructors and students. While the text is provided to students electronically at no cost with options to order low cost print on demand versions, an optional and fair license fee is charged for the use of the formative online assessment in exchange for student and instructor support, editorial services to adapt the content, and all other needed supplementary material.  
  
Lyryx Learning was started in the Mathematics Department at the University of Calgary, and is now a complete and independent publisher of educational material for the higher education sector.
3. Nataliya Zadorozhna  
MacEwan University  
Title: Junior High Math in Alberta  
Abstract: Currently Alberta’s secondary education system is failing to prepare students for post-secondary education. This is something I have experienced both professionally with the students I teach at MacEwan University, and personally through my son who is attending a junior high school in Edmonton. During my presentation, I will be using personal examples of my experience with the junior high system and will make suggestions for its improvement.

4. Publisher-Pearson  
Title: Active Learning with Pearson Education  
Abstract: This talk is about how Pearson tools, specifically MyMathLab and MyStatLab, are designed to support Active Learning.
5. Manny Estabrooks  
Red Deer College  
Title: Digital Schemes in Learning vs the Multi-Dimensional Aspects of Pen and Paper Methods to Promote Learning Mathematics  
Abstract: As the many features of on line learning evolve, let's not forget the tried and proven methods utilizing Pen and paper techniques for learning and problem solving. Pen and paper methods utilize many of the truly human senses such as visual, tactile, cognitive and musculature in learning and the recall of facts. Perhaps we should encourage the often put down activity of doodling to stimulate the brain in making connections and recall of information
6. Brett McCollum  
Mount Royal University  
Title: Helping students read mathematics  
Abstract: Do most university students read their textbooks? Evidence suggests the answer is 'no'. Can university students read university-level textbooks? Shockingly, many faculty say the answer is 'no'. Flipping the classroom has been a popularized method for increasing student engagement with course concepts. This has been particularly embraced within mathematics and science education. However, the use of preparatory videos, as proposed by Bergmann and Sams (2012), has been found to further suppress student textbook reading habits. A flipped-learning approach in a 1st year course was supported with Academic Reading Circles (Shelton-Strong, 2011; Seburn, 2015), a STEM HyperLibrary open-education textbook (Allen et al., 2015), and in-class teaching assistants. Increased levels of student preparatory reading and exam performance were observed. In this session you will learn how to facilitate student engagement with academic texts, as well as how you can contribute to, and benefit from, the MathWiki Project.
7. Nikolay Bukharin  
Southern Alberta Institute of Technology (SAIT)  
Title: Problems of SAIT students mathematical background for studying theoretical mechanics.  
Abstract: In this talk I will report on my experience teaching Dynamics and Engineering Statics at Southern Alberta Institute of Technology. These two courses are very challenging for students and often considered as so called "killer courses" on engineering programs, courses with high rates of unsuccessful outcomes (D, F, and Withdrawals).  
In my opinion the main problem of high fail rates is related to students weak mathematical background. I would like to discuss specific gaps in

mathematics knowledge which lead to difficulties of understanding dynamics and statics, classify them and share my experience in dealing with these gaps and low motivation among students.

8. Roberta La Haye  
Mount Royal University  
Title: String Art and Visual Calculus -New Ways to Present Tangent Lines in Calculus Class  
Abstract: Tangent lines are usually a pretty dull topic in Introductory Calculus textbooks. I will discuss 2 interesting ways they have been used to generate art and calculate areas.
9. Publisher-Nelson  
Title: MindTap Math Foundations  
Abstract: Attached in the last page.
10. Digby Smith  
Mount Royal University  
Title: The Endless Search in the Morass Beyond Infinity for The Centre Of Civilization : Thoughts On Problem Solving In Mathematics  
Abstract: An expression of fun with a gathering of a handful of considerations and problems dealing with problem solving.
11. Publisher-Macmillan  
Title: Helping Students Understand and Practice with LaunchPad  
Abstract: We will be talking about media/digital resources and how it has the ability to help students outside the classroom.
12. Wanhua Su  
MacEwan University  
Title: Course Evaluation and Reflection  
Abstract: Obtaining feedback and reflection is an essential component in teaching and learning. In this talk, I will start with a brief overview of the course evaluation system at MacEwan University. I will share some of my approaches to obtaining feedback. As well I will share how I reflect on the feedback received, and how this reflection improves my teaching.
13. Round Table: "Schemes in Place to Address to the Changing Needs of First Year Student in Mathematics Courses"  
What are the various institutions doing to address this issue Pre-requisite for the courses (minimums etc), Assessment tests?

### 3 Financial Mathematics

Session Chair: Alexander Melnikov, University of Alberta

1. Anna Glazyrina  
University of Alberta  
Title: Quadratic hedging of equity-linked life insurance contracts in discrete time  
Abstract: We solve a problem of hedging in incomplete markets through quadratic criterion under the assumptions of frictionless market and discrete time. Pricing and hedging algorithms are implemented by means of finding a P-discounting portfolio (a numeraire) such that discounted price processes are martingales under the physical measure P. The applications in pricing and hedging of equity-linked life insurance contracts are demonstrated.
2. Alex Badescu  
University of Calgary  
Title: Non-affine GARCH option pricing models, Variance dependent kernels, and diffusion limits.  
Abstract: This paper investigates the pricing and weak convergence of an asymmetric non-affine, non-Gaussian GARCH model when the risk neutralization is based on a variance dependent exponential linear pricing kernel with stochastic risk aversion parameters. The risk-neutral dynamics are obtained for a general setting and its weak limit is derived. We show how several GARCH diffusions, martingalized via well-known pricing kernels, are obtained as special cases and we derive necessary and sufficient conditions for the presence of financial bubbles. An extensive empirical analysis using both historical returns and options data illustrates the advantage of coupling this pricing kernel with non-Gaussian innovations.
3. Amir Nosrati  
University of Alberta  
Title: Efficient hedging for defaultable securities and its application to equity-linked life insurance contracts.  
Abstract: In this talk, we consider the efficient hedging problem for defaultable securities with multiple default times and non-zero recovery rates. First, we convert the underlying efficient hedging problem into a Neyman-Pearson problem with composite hypothesis against a simple alternative. Then we apply non-smooth convex duality to provide a solution in the framework of a 'defaultable' Black-Scholes model. Moreover, in the case of zero recovery rates, we find a closed form solution for the problem. As an application, it is shown how to use such type of results in pricing equity-linked life insurance contracts. The results are also demonstrated by some numerical examples.

4. Ilnaz Asadzadeh  
University of Calgary  
Title: Semi-parametric time series modeling with auto-copulas.  
Abstract: TBA
5. Zijia Wang  
University of Calgary  
Title: Pricing Oil Futures Options Under Heston's and Bate's Models.  
Abstract: In recent time, crude oil prices have exhibited significant jumps, which cannot be accounted for in a diffusion model with continuous path. Our main purpose is to price oil future options (CLM16 and CLJ16) under Heston's and Bate's models and to evaluate the accuracy. We will give an overview of Markov Chain Monte Carlo (MCMC) simulation which is a powerful tool for calibration of parameters, discuss the effect of adding jump term to models, compare the estimated options prices with actual prices to evaluate goodness of fit.
6. Jonathan Allan Chavez Casillas  
University of Calgary  
Title: Price dynamics in a level 1 Limit Order Book.  
Abstract: In this talk we will discuss briefly two models of a Limit Order Book. Both models are generalizations of the model presented by Cont and de Larrard (2012). However, in the first, we will try to capture properties of the so-called small tick stocks where the spread may widen constantly. In the second, the aim is to capture the time dependency of the rates governing the point processes describing the arrivals of limit orders, market orders and cancellations. In both cases, the long-run dynamics of the price process is analyzed.

## 4 Algebra & Number Theory

Session Chair: Eric Roettger, Mount Royal University

1. Bin Xu

University of Calgary

Title: On the combinatorial structure of Arthur packets:  $p$ -adic symplectic and orthogonal groups

Abstract: The irreducible smooth representations of Arthur class are the local components of automorphic representations. They are conjectured to be parametrized by the Arthur parameters, which form a subset of the usual Langlands parameters. The set of irreducible representations associated with a single Arthur parameter is called an Arthur packet. Following Arthur's classification theory of automorphic representations of symplectic and orthogonal groups, the Arthur packets are now known in these cases. On the other hand, Mœglin independently constructed these packets in the  $p$ -adic case by using very different methods. In this talk, I would like to describe a combinatorial procedure to study the structure of the Arthur packets following the works of Mœglin. As an application, we show the size of Arthur packets in these cases can be given by counting integral (or half-integral) points in certain polytopes.

2. Andrew Fiori

University of Calgary

Title: Morphisms in the Category of Algebraic Groups over a Field

Abstract: We will discuss the general problem of concretely describing the morphisms in category of algebraic groups over field. I will briefly survey some of the challenges and illustrate the approach in the case of maps between simply connected groups of type  $A_2$  and groups of type  $G_2$ .

3. Carlos R. Videla

Mount Royal University

Title: A note on the Northcott property and undecidability

Abstract: I will speak about a natural relation between the Northcott property for sets of algebraic numbers and the Julia Robinson number associated to sets of totally real algebraic integers. I will show how we can obtain undecidability results for fields using a theorem of Bombieri and Zannier and a theorem of the speaker. This is joint work with X. Vidaux of the University of Concepcion, Chile.



## 5 Combinatorics & Discrete Mathematics

Session Chair: Micheal Cavers, University Calgary

1. Michael Cavers

University of Calgary

Title: The distinguishing chromatic number of a graph

Abstract: Given a ring of keys that open different doors but appear identical to one another, how many key labels are needed to distinguish between them? This problem motivates the distinguishing number of a graph, introduced by Albertson and Collins in 1996, and is defined to be the minimum number of labels required to label the vertices of a graph so that the only automorphism of the graph which preserves labels is the identity. In 2005, Collins and Trenk defined the distinguishing chromatic number of a graph which requires the labelling to also be a proper colouring. We look at graphs with large distinguishing chromatic number along with the effect some operations on graphs have on this number and some special classes of graphs.

2. Muhammad Khan

University of Calgary

Title: Advances on the Caccetta–Häggkvist conjecture and related problems

Abstract: In the theory of digraphs, the study of cycles in general and short cycles in particular is a subject of great importance. Much of this interest stems from the longstanding Caccetta–Häggkvist conjecture, which states that every oriented graph of order  $n$  with minimum outdegree at least  $k$  has a cycle with length at most  $\lceil n/k \rceil$ . Formulated in the 1970's, it is widely regarded as one of the most important unsolved problems in graph theory. In this talk we show that it suffices to study this conjecture for a very special class of oriented graphs, since if the statement is true for the graphs in this class it holds for all oriented graphs. This greatly clarifies matters by pinpointing where the difficulty lies in proving the Caccetta–Häggkvist conjecture. We also investigate related conjectures raised by Seymour and Thomassé and present some of our results about them.

3. Kris Vasudevan

University of Calgary

Title: Influence of signs on Ramanujan graphs

Abstract: Spectral theory for dynamics on undirected and directed graphs containing only attractive (or positive) interactions has been the subject of detailed research studies. However, in many applied problems, these graphs can carry interactions which are repulsive (or negative) to a certain degree. We have investigated how properties of signed graph Laplacians change for differing ratios of negative interactions to positive interactions. We have also looked into how these changes affect the outcome

of Kuramoto model dynamics. We have extended these studies to determine the influence of sign on the Laplacians of Lubotzky-Phillips-Sarnak (or LPS) -style Ramanujan graphs. We have used this to understand the phase-synchronization behaviour of weakly-coupled oscillators on such Ramanujan graphs.

4. Kai Fender

University of Lethbridge

Title: Recursively-constructed unit Hadamard: their excess and a resulting family of BIBDs

Abstract: A unit Hadamard matrix is a square matrix  $H$  with unimodular entries and mutually orthogonal row vectors. If the entries of  $H$  are all roots of unity,  $H$  is a Butson Hadamard matrix. If the entries of  $H$  are all 1 or -1,  $H$  is a Hadamard matrix. In the second half of the twentieth century interest arose in finding the maximal modulus of the sum of the entries, or the excess, of a unit Hadamard matrix. In this talk, we will give a recursive construction for infinite classes of Hadamard, Butson Hadamard and unit Hadamard matrices. We will proceed to use these classes to obtain several lower bounds for the maximal excess problem. Finally, we will show that some of our recursively-constructed Hadamard matrices can be used to construct an infinite class of balanced incomplete block designs, another important combinatorial object.

5. Keivan Hassani Monfared

University of Calgary

Title: Combinatorial bounds for the maximum eigenvalues of graphs

Abstract: For a graph  $G$ ,  $M(G)$  denotes the maximum multiplicity occurring of an eigenvalue of a symmetric matrix whose zero-nonzero pattern is given by edges of  $G$ . In this talk we introduce two combinatorial graph parameters that give a sharp lower bound and a sharp upper bound for  $M(G)$ .

6. Haotian Song

University of Calgary

Title: The 2 Disjoint Shortest Paths Problem with Distance Constraints

Abstract: An electric power supplier needs to build a transmission line between 2 jurisdictions. Ideally, the design of the new electric power line would be such that it maximizes some user-defined utility function, for example, minimizes the construction cost or the environmental impact. Due to reliability considerations, the power line developer has to install not just one, but two transmission lines, separated by a certain distance from one to another, so that even if one of the lines fails, the end user will still receive electricity along the second line. We discuss how such a problem can be modeled and prove the graph-based problem to be NP-hard. In addition, we demonstrate an approximate setting that allows us to solve this problem in polynomial time.

## 7. Samuel Reid

University of Calgary

Title: On Arrangements of Six, Seven, and Eight Spheres: Maximal Bonding of Monatomic Ionic Compounds

Abstract: Let  $C(n)$  be the solution to the contact number problem, i.e., the maximum number of touching pairs among any packing of  $n$  congruent spheres in  $\mathbb{R}^3$ . We prove the long conjectured values of  $C(6) = 12$ ,  $C(7) = 15$ , and  $C(8) = 18$ . The proof strategy generalizes under an extensive case analysis to  $C(9) = 21$ ,  $C(10) = 25$ ,  $C(11) = 29$ ,  $C(12) = 33$ , and  $C(13) = 36$ . These results have great importance for condensed matter physics, materials science, crystallography, organic and physical chemistry of interfaces.

## 6 Differential Equations and applications

Session Chair: Ion Bica, MacEwan University.

1. Oluwole Olobatuyi

University of Alberta

Title: A Reaction-Diffusion Model for Secondary Effects of Radiation on Cell Survival

Abstract: We consider the survival of cells in response to radiation. Historically, survival fraction as a function of radiation dose has been modelled by the Linear Quadratic model, which is a monotonically decreasing function. However, experiments have shown that cells exhibit hyper-radiosensitivity (HRS) at very low doses while cells exhibit increased radio-resistance (IRR) at slightly higher doses, resulting in a nonmonotonic curve. One of the hypotheses proposed to explain the HRS/IRR phenomenon is that at low doses, cells die as a result of secondary radiation effects, also known as bystander effects. We develop a three-dimensional model of reaction-diffusion equations describing the role of bystander effects on cell survival. We show through simulations that our model exhibits the HRS/IRR phenomenon. Through sensitivity analysis, we identified key model parameters that play a role in the emergence of the HRS/IRR phenomenon. We also use bifurcation analysis to explain why, in some cases, the bystander effects can outlive the primary radiation effects on irradiated cells. Our results contribute to the current understanding of cell survival at low doses and may have implications for the application of radiotherapy.

2. Adrian Biglands

MacEwan University

Title: Ranking Problems Arising from ODE Models on Networks

Abstract: The use of ordinary differential equations modeled on networks has become an increasingly important technique in many areas of research. The local behaviour of a system is modeled with differential equations and interactions between members or nodes are described using weighted digraphs. For instance, in public health nodes can represent different groups of people affected by an infectious disease, while edges in the network represent the cross-infection between the groups. The local behaviours of the disease in each group are described with ODE dynamics. In ecology, the spatial dispersal of one or more species considers the habitation patches as nodes and the edges between nodes describe the movement of the species between patches.

This talk describes a method of ranking the nodes of an ODE network at a positive equilibrium called an equilibrium ranking. More specifically, assuming an ODE system modeled on a network  $(G, B)$  has a positive equilibrium  $\mathbf{x}$ , we associate to node  $i$  of the network. These positive equilibrium values are used to rate, and hence rank, the individual nodes of the

network. Such an equilibrium ranking reflects both the graph structure and the local ODE parameters of the model.

3. Zhichun Zhai

MacEwan University

Title: Recent Developments on the Euler-Poincaré Equation

Abstract: The Euler-Poincaré equation has many applications in science and engineering. It is also closely related to several famous PDEs in fluid dynamics. For a large class of smooth initial data, we prove that the corresponding solution blows up in finite time. This settles an open problem raised by Chae and Liu (Commun Math Phys 314:671-687, 2012). Our analysis exhibits some new concentration mechanisms and hidden monotonicity formulas associated with the Euler-Poincaré flow. In particular, we show an abundance of blowups emanating from smooth initial data with certain sign properties. Moreover, we showcase a class of initial data for which the corresponding solution exists globally in time. This is joint work with Dong Li and Xinwei Yu.

4. Arianna Bianchi

University of Alberta

Title: Mathematical Models for Wound Healing Lymphangiogenesis

Abstract: Several studies suggest that one possible cause of impaired wound healing is failed or insufficient lymphangiogenesis, that is the formation of new lymphatic capillaries. Although many mathematical models have been developed to describe the formation of blood capillaries (angiogenesis) very few have been proposed for the regeneration of the lymphatic network. Moreover, lymphangiogenesis is markedly distinct from angiogenesis, occurring at different times and in a different manner, which is still poorly understood.

Here three different mathematical models are presented; an ODE model exploring lymphatic regeneration dynamics in normal and diabetic subjects, and two PDE models comparing different hypotheses proposed by biologists to explain the cellular mechanism driving lymphangiogenesis after a skin wound. These models give further insight into the phenomenon in question and might be used to design new therapeutic strategies.

5. Ion Bica

MacEwan University

Title: Modeling Kadomtsev-Petviashvili

Abstract: In 1970 Boris Kadomtsev and Vladimir Petviashvili brought a correction to the KdV model, model that was introduced by Diederik Korteweg and Gustav de Vries in 1895. Kadomtsev and Petviashvili addressed the one spatial dimensionality of the KdV model by adding to the model a second weak spatial dimension, as they were interested to study the stability of a solitary wave when the wave had a weak bending distortion whose amplitude and phase were slowly varying functions of the coordinate  $y$ , measured transversely with respect to the solitary waves'

direction of propagation (the x-axis). The way they introduced the correction to the KdV model was based on experimental Physics. In this talk I will give an intuitive mathematical derivation of the KP model followed by a very rigorous Physical derivation of the model, for the purpose of understanding the high complexity of this

6. Mariya Svishchuk  
Mount Royal University  
Title: Clustered model of disease spreading  
Abstract: An averaging principle for the Kermack-McKendrick model in semi-Markov random media have been considered. Under stationary conditions the perturbed endemic model converges to the averaged SIR model. Various limit theorems for random evolutions have been applied for averaging and diffusion approximation.
7. Hatéf Dastour  
University of Calgary  
Title: A Mollified Marching Solution of an Inverse Degenerate Diffusion Problem in Petroleum Reservoir  
Abstract: This study deals with the numerical solution of a nonlinear inverse degenerate diffusion problem in the petroleum reservoirs. A computational procedure based on the discrete mollification method and the space marching scheme is developed to solve the proposed inverse problem. The stability and convergence of the numerical solution are proved. To demonstrate the effectiveness and accuracy of the new method, two numerical examples are solved. Numerical results show that the new method is effective in solving inverse problem when noisy data is used.
8. Hassan Safouhi  
University of Alberta  
Title: New formulae for differentiation and techniques in numerical integration  
Abstract. We present new formulae, called the Slevinsky-Safouhi's formulae (SSF) I and II [1] for the analytical development of derivatives. The SSF, which are analytic and exact, represent the kth derivative as a discrete sum of only  $k + 1$  terms. The coefficients that are involved in the summation can be computed recursively and they are not subject to any computational instability. There are numerous applications in science and engineering for special functions and higher order derivatives. As an example, the nonlinear G transformation [2] has proven to be a very powerful tool in numerical integration [3, 4]. However, this transformation require higher order successive derivatives of the integrands for the calculation, which can be a severe computational impediment. In highly oscillatory integrands, special functions are prevalent. As examples of applications of the SSF, we present higher order derivatives of Bessel functions which are prevalent in oscillatory integrals and provide tables illustrating our results. We also present an efficient recursive algorithm for the implementation of

the G transformation and which we use to compute the incomplete Bessel functions and tail integrals of probability distributions. Lastly, we present a generalized and formalized integration by parts to create equivalent representations to some challenging integrals, which we apply to challenging integrals such as the Twisted tail which is proposed as a challenge in "The SIAM 100- digit challenge. A Study in High-Accuracy Numerical Computing". References ]

## 7 Operator Theory

Session Chair: Brady Killough, Mount Royal University

1. Martin Argerami  
University of Regina  
Title: Three-Dimensional Operator Systems  
Abstract: TBA
2. Cristian Ivanescu  
MacEwan University  
Title: The Cuntz semigroup of the tensor product of  $C^*$ -algebras  
Abstract: In the early 2000s, work by A. Toms prompted major questions regarding the Cuntz semigroup. In our work we study how the Cuntz semigroup of the tensor product of two identical algebras  $A \otimes A$  relates to the Cuntz semigroup of  $A$ . A natural tensor product map can be constructed. We report on surjectivity and injectivity property of this map. This is a joint work with Dan Kucerovsky (UNB).
3. Vladimir Troitsky  
University of Alberta  
Title: Multinormed spaces  
Abstract: In a normed space, the norm of a vector represents its “size”. It is often important to measure the “total size” of a (finite or infinite) sequence of vectors. This idea leads to the concept of a multinorm. In this talk, I will discuss several variants of definitions of multinorms. I will also present a representation theorem: every multinorm can be represented as a subspace of a Banach lattice. This is a joint work with G.Dales, N.Laustsen, and T. Oikhberg.
4. Gilad Gour  
University of Calgary  
Title: On local multiplicativity of the  $L_p$  norms of a quantum channel  
Abstract: One of the major open problems in quantum information concerns with the question whether entanglement between signal states can help to send classical information on quantum channels. Recently, Hastings proved that entanglement does help by finding a counter-example for the long standing additivity conjecture that the minimum von-Neumann entropy output of a quantum channel is additive under taking tensor products. In this talk I will show that the minimum von-Neumann entropy output of a quantum channel, as well as all other Renyi entropies with parameter  $p > 1$ , are locally additive. Hastings’s counterexample for the global additivity conjecture, makes this result somewhat surprising. In particular, it indicates that the non-additivity of the minimum entropy output is related to a global effect of quantum channels. I will end with few related open problems.



## 5. Marko Kandić

University of Ljubljana

Positive commutators of positive operators on Banach lattices

Suppose that  $A$  and  $B$  are positive operators on a Banach lattice  $E$  with a positive commutator  $AB - BA$ . In this talk we will be interested in spectral properties of  $AB - BA$ . If at least one of operators  $A$  and  $B$  is compact, then  $AB - BA$  is quasinilpotent. We will also consider the question of invertibility of  $AB - BA$ .

## 6. Berndt Brenken

University of Calgary

Title:  $C^*$ -algebras from representations of  $*$ -semigroups.

Abstract: A  $C^*$ -algebra is a norm closed algebra of operators on a Hilbert space which is closed under taking adjoints. Representing groups via groups of unitary operators on Hilbert space lead naturally to considering operator algebras involving group actions implemented by unitary groups. Recently  $C^*$ -algebras associated with (discrete) graphs have been introduced and intensively studied; these involve highly structured inverse semigroups of partial isometries.

A map implemented by a partial isometry is a linear contraction, but such maps also possess strong order preserving properties involving matrices. Partial isometries generate  $*$ -semigroups. We consider  $*$ -semigroups, a class containing groups and inverse semigroups, and introduce order structures involving matrices. Examples illustrating such orders are given.

## 7. Mohammad A. A. Marabeh

Middle East Technical University (METU)

Title: Unbounded Order Continuous Operators

Abstract: A net  $(x_\alpha)$  in a Riesz space  $E$  is unbounded order convergent (uo-convergent) to  $x \in E$  if the net  $(|x_\alpha - x| \wedge y)$  order converges to 0 for all  $y \in E_+$ . A linear operator between Riesz spaces is said to be *unbounded order continuous* (*uo-continuous*) whenever the image of an uo-null net is uo-null, and it is said to be  *$\sigma$ -unbounded order continuous* ( *$\sigma$ uo-continuous*) if the image of an uo-null sequence is uo-null.

We begin this talk by recalling order convergence and unbounded order convergence in Riesz spaces. Then we demonstrate a literature review on uo-convergence. After that, some characterizations of uo-convergence will be illustrated. Next we give some properties of uo-continuous and  *$\sigma$ uo-continuous* operators. Finally we characterize the *uo-continuous* (respectively,  *$\sigma$ uo-continuous*) dual of some well-known Riesz spaces.

## 8. Adi Tcaciuc

MacEwan University

Title: On almost-invariant subspaces

Abstract: We show that any bounded operator  $T$  on a separable, reflexive, infinite-dimensional Banach space  $X$  admits a rank one perturbation

which has an invariant subspace of infinite dimension and codimension. We also prove that many such perturbations can be found when the spectrum of  $T$  is countable

## 8 Mathematics & Statistics

Session Chair: Pamini Thangarajah, Petr Zizler, Mount Royal University

1. Cat-Tuong Huynh (presenter), Kelsey Sly  
University of Alberta  
Title: Maths for Drinkers ? Blood Alcohol Concentration Modelling  
Abstract : Mathematics has always been misunderstood as a boring and unrealistic field for one to pursue. Our project proves that mathematics is a powerful tool for solving problems in our life through exploring mathematical models for calculating blood alcohol concentration (BAC). BAC models in both discrete and continuous manners that taken into account real factors, such as gender, body weight, are developed. Moreover, graphical results from these models are generated using Excel and Maple softwares. Results from our model analysis can be used to inform the public about responsible use of alcohol. Also, using our model, one can determine their drinking mode before going to a party, in order to avoid alcohol poisoning.
- 2.
3. Matthew Pietrosanu  
University of Alberta  
Title: Uncovering structure in data with persistent homology: theory and an application to linguistic word association networks.  
Abstract: Persistent homology is a technique recently-developed in algebraic and computational topology well-suited for analysing structure in complex, high-dimensional data. In this presentation, we discuss the significance and meaning of structure and shape in data, and present persistent homology as a technique to recover the underlying topology of a dataset. We give an introductory and intuitive overview of this method and, in particular, detail an application of persistent homology to the analysis of associations between words of the English language.
4. Philippe Gaudreau and Hassan Safouhi  
University of Alberta  
Title: The Double Exponential Sinc Collocation Method for Solving Quantum Mechanical Problems  
Abstract. The Sinc collocation method (SCM) has been used extensively during the last three decades to solve many problems in numerical analysis [1]. Their applications include numerical integration, linear and non-linear ordinary differential equations. The double exponential transformation [2] yields optimal accuracy for a given number of function evaluations when using the trapezoidal rule in numerical integration. Recently, combination of the SCM with the double exponential (DE) transformation has sparked great interest [3]. In this talk, we present a method based on the double

exponential Sinc collocation method (DESCM) for solving singular Sturm-Liouville and anharmonic oscillator eigenvalue problems to unprecedented accuracy. Sturm-Liouville equations are abundant in the numerical treatment of scientific and engineering problems. For example, Sturm-Liouville equations describe the vibrational modes of various systems, such as the energy eigenfunctions of a quantum mechanical oscillator, in which case the eigenvalues correspond to the energy levels. Sturm-Liouville problems arise directly as eigenvalue problems in one space dimension. They also commonly arise from linear PDEs in several space dimensions when the equations are separable in some coordinate system, such as cylindrical or spherical coordinates. The one dimensional anharmonic oscillator is of great interest to field theoreticians because it models complicated fields in one-dimensional space-time. The study of quantum anharmonic oscillators as potentials in the Schrödinger equation has been on the edge of thrilling and exciting research during the past three decades [4?8]. Numerous approaches which have been proposed to solve this problem and while several of these methods yield excellent results for specific cases, it would be favorable to have one general method that could handle efficiently and accurately any anharmonic potential. The DESCM starts by approximating the wave function as a series of weighted Sinc functions in the eigenvalue problem and evaluating the expression at several collocation points spaced by a given mesh size  $h$ , we obtain a generalized eigensystem which can be transformed into a regular eigenvalue problem. For multiple-well potentials, we introduce an alternate and more effective mesh size  $h$  leading to a considerable improvement of accuracy. The method is shown to have a near-exponential convergence rate.

##### 5. Md Mahsin

Md Mahsin [1] John Petkau [2] Yinshan Zhao Title: Determination of Sample Size for Phase II Clinical Trials in Multiple Sclerosis using Lesional Recovery as an Outcome Measure Abstract: Multiple sclerosis (MS) is an inflammatory demyelinating disease of the central nervous system. The hallmark feature of the disease is the formation of focal demyelinating lesions accompanied by myelin destruction in the white matter (WM). Magnetic resonance imaging (MRI) is used identify and visualize these lesions. Repeated MRI scanning of patients (most often monthly) over period of months has become a standard protocol for Phase II trials of experimental treatment in MS. The formation of WM lesions in MS is characterized by inflammatory demyelination and then remyelination usually occurs over several months after lesion formation. Hence, a measure reflecting lesional recovery is a promising outcome for phase II clinical trials that assess the effect of therapies intended to induce remyelination. Our objective is to provide sample sizes required to detect such an experimental treatment effect with certain statistical power. We consider a parallel group design with two arms of equal number of subjects. The study design is considered as a three level hierarchical data structure where lesions are nested

within subjects and are assessed repeatedly over the study period. Variable numbers of new enhancing lesions per subject and variable numbers of measurements at before and after enhancement (depends on the time of the lesion's appearance) are also considered. The numbers of subjects in each treatment arm necessary to obtain statistical powers of 80% or 90% are determined for different numbers (6, 9, 12) of monthly follow-up scans. A mixed-effects linear regression model is used for this sample size determination. This is a joint work with John Petkau and Yinshan Zhao.

6. Soumen Sarkar

University of Calgary

Title: Some Aspects of Equivariant LS-category

Abstract: In this talk, I will compute the lower bounds and upper bounds for LS-category and equivariant LS-category. I will discuss the equivariant LS-category of the product space and some counterexamples of two previous results. This is a joint work with M. Bayeh.