Tenth Annual PIMS Young Researchers Conference in Mathematics and Statistics

(PIMS YRC 2013)

University of Alberta, Edmonton, AB, Canada
May 21-24, 2013

Schedule and Abstracts

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would like to express their gratitude to Dana Gauthier and Leona Guthrie for their indispensable assistance in organizing the 10th PIMS YRC, and would like to thank the 10th PIMS YRC's sponsors for their support:

Tuesday, May 21

11:00 - 12:45: Registration in CAB 528
12:45 - 13:00: Welcome in SAB 325
13:00 - 14:00: Plenary talk by **Mark Lewis** in SAB 325
14:15 - 15:15: Scientific talks
15:15 - 15:45: Coffee break in CAB 528
15:45 - 17:15: Scientific talks
17:30 - 21:00: BBQ in Main Quad

Jasper Session, CAB 528

14:15 - 14:45	*Bilateral Series and Ramanujan's Mock Theta Functions	Jitendra Bajpai	UA
14:45 - 15:15	Detecting Algebraic Cycles through Height Pairing	Souvik Goswami	UA
15:15 - 15:45	**Coffee break**		
15:45 - 16:15	*Hypergroups and projections	Nazanin Tahmasebi	UA
16:15 - 16:45	*Isoperimetric Inequalities for k-Hessian Capacity	Ning Zhang	MUN

Banff Session, CAB 269

14:15 - 14:45	*A mathematical investigation of plasma membrane heterogeneity	Rochelle Nieuwenhuis	UA
14:45 - 15:15	*Deriving space use patterns from animal interaction mechanisms	Jonathan Potts	UA
15:15 - 15:45	**Coffee break**		
15:45 - 16:15	HIV, Data, and Identifiability	Rebecca de Boer	UA
16:15 - 16:45	*A Phage-Bacteria Petri Dish Model in Different Types of Media: Nutrient-Limited Growth, Movement, and Predation	Silogini Thanarajah	UA
16:45 - 17:15	*A Historical Overview of the Turbulent Autoconversion Process in Droplet Size Evolution	David Collins	UV

Wednesday, May 22

09:00 - 10:30: Scientific talks
10:30 - 11:00: Coffee break in CAB 528
11:00 - 12:00: Workshop Part I with **Gerda de Vries** in SAB 326
13:00 - 14:00: Plenary talk by **Terry Gannon** in SAB 325
14:15 - 15:15: Scientific talks
15:15 - 15:45: Coffee break in CAB 528
15:45 - 17:15: Scientific talks

Jasper Session, CAB 528

09:00 - 09:30	SYZ conjecture on Calabi–Yau threefolds of type K	Atsushi Kanazawa	UBC
09:30 - 10:00	*Poincaré series map on open Riemann surfaces	Nadya Askaripour	UC
10:00 - 10:30	TBA	Stefan Mendez-Diez	UA
10:30 - 11:00	**Coffee break**		

Jasper Session, CAB 281

14:15 - 14:45	*Khinchine inequality for slightly dependent random variables	Susanna Spektor	UA
14:45 - 15:15	*A short introduction to John's theorem, with applications	Steven Taschuk	UA
15:15 - 15:45	**Coffee break**		
15:45 - 16:15	*Heegner Points: A marriage of algebra, analysis and geometry	Jordan Kostiuk	UA
16:15 - 16:45	*The game of BASIC MANCALA	Maximiliano Liprandi	UC

Banff Session, CAB 269

09:00 - 09:30	*Post-transplant Lymphoproliferative Disorders: Novel Risk Factors and a Mathematical Model	Michael Akinwumi	UA
09:30 - 10:00	*Modeling Brain Tumour Spread Using Anisotropic Diffusion	Amanda Swan	UA
10:30 - 11:00	Break		
10:30 - 11:00	**Coffee break**		
14:15 - 14:45	*Optimal Portfolio Versus No-arbitrage and Its Application	Jun Deng	UA
14:45 - 15:15	*Explicit Formula for the Optimal Government Debt Ceiling	Ricardo Huaman	UA
15:15 - 15:45	**Coffee break**		
15:45 - 16:15	*Prediction of HIV prevalence in China	Zhimin Su	UA

Thursday, May 23

09:00 - 10:30: Scientific talks
10:30 - 11:00: Coffee break in CAB 528
11:00 - 12:00: Workshop Part II with **Gerda de Vries** in CAB 528
13:00 - 14:00: Plenary talk by **Sergei Petrovskii** in SAB 325
14:15 - 15:15: Scientific talks
15:15 - 15:45: Coffee break in CAB 528
15:45 - 17:15: Scientific talks
19:00 - 22:00: Faculty of Science Banquet in Lister Conference Centre

Jasper Session, CAB 528

09:00 - 09:30	Can we hear the shape of a drum?	Mark Sebestyen	UA
09:30 - 10:00	*An Introduction to Lattices And Their Applications	Rebecca Meissen	UC
10:00 - 10:30	*Class Numbers and Continued Fraction Expansions	Michael Wanless	UC
10:30 - 11:00	**Coffee break**		
14:15 - 14:45	On Barzilai and Borwein gradient method for large scale optimization problem	Yipin Guo	UBCO
14:45 - 15:15	Hopf Invariant and LS-Category	Marzieh Bayeh	UR
15:15 - 15:45	**Coffee break**		
15:45 - 16:15	*Hypoellipticity of infinitely degenerate elliptic operators	Timur Akhunov	UC
16:15 - 16:45	*Weighted Hardy-Littlewood-Sobolev Inequality on the unit sphere	Han Feng	UA

Banff Session, CAB 265

09:00 - 09:30	Jointpoint Regression Estimation using LASSO Variable Selection	Matus Maciak	UA
09:30 - 10:00	*Applications of hybrid monte carlo methods to Bayesian logistic and t-probit models in genomic studies	Lai Jiang	US
10:00 - 10:30	*Bayesian Inference for Gene Networks	Abdollah Safari	SFU
10:30 - 11:00	**Coffee break**		

Banff Session, CAB 269

14:15 - 14:45	*A spatial model with generalized logistic type growth and a carrying capacity driven diffusion	Md Kamrujjaman	UC
14:45 - 15:15	*Direction-dependent communication mechanisms in models of collective behaviour	Cole Zmurchok	UA
15:15 - 15:45	**Coffee break**		
15:45 - 16:15	*Google's PageRank for Analyzing Metabolic Networks	Shi Qiu	US
16:15 - 16:45	*Application of Hawkes process to historical data	Boyko Zlatev	UA

Friday, May 24

09:00 - 10:30: Scientific talks
10:30 - 11:00: Coffee break
11:00 - 12:00: Plenary talk by **Duncan Murdoch** in SAB 336
12:15 - 13:30: Lunch (catered) and farewell in CAB 528

Jasper Session, CAB 528

09:00 - 09:30	Useful Pointless Abstract Nonsense: A Handshake with Topoi	Yuri Delanghe	UA
09:30 - 10:00	On equivariant cobordism of torus orbifolds	Soumen Sarkar	UR
10:00 - 10:30	*Inverse Galois Problem: Example of group of low degree	Francois Amalega	UM

Banff Session, SAB 336

09:00 - 09:30	*Finite convergence of subgradient projection method	Jia Xu	UBCO
09:30 - 10:00	*Double Exponential Sinc-Collocation Methods for Computing Energy Levels of the Schrodinger Equation with Anharmonic Potentials	Richard Slevinsky	UA
10:00 - 10:30	*On Benford's law in dynamical systems	Gideon Eshun	UA

Plenary Talks

Moonshine: where Algebra meets Number Theory meets Physics

by **Terry Gannon**
University of Alberta

196883, the smallest nontrivial number the Monster knows, almost equals 196884, the first nontrivial number intimate with the j-function. Could there be a relation between the Monster, the most exceptional of all groups, and the j-function, the mother-of-all modular forms? The answer is yes, and the reason is string theory. In my talk I'll explain what all this means, why we should care, and what comes next.

Mathematical Models for Territorial Interaction

by **Mark Lewis**
University of Alberta

Mathematical models can help us understand the formation of complex spatial patterns, including the territories of wolves and coyotes. Here scent marks provide important cues regarding the use of space. In this talk I will show how biologically-based mechanistic rules can be put into a mathematical model which predicts the process of territorial formation as individuals create and respond to scent marks. The model predicts complex spatial patterns which are seen in nature, such stable "buffer zones" between territories which act as refuges for prey such as deer. The mathematical work is supported by detailed radio-tracking studies of animals. I will also employ the approach of game theory, where each pack attempts to maximize its fitness by increasing intake of prey (deer) and while decreasing interactions with hostile neighboring packs. Here the predictions are compared with radio-tracking data for wolves and coyotes. Finally I will show how a version of the territorial model has been applied to human populations in understanding spatial patterns arising from conflict between urban gangs.

Sampling from Unknown Distributions

by **Duncan Murdoch**
University of Western Ontario

We all know that small samples don't tell us very much about the underlying distributions from which they were sampled. It is somewhat surprising that a converse exists: we can sample from a distribution without knowing very much about it! In this talk I will discuss applications of this idea, from adaptive rejection sampling to so-called "perfect sampling".

A tale of two tails: dispersal in a population of non-identical individuals

by **Sergei Petrovskii**
University of Leicester

The rate of decay in the population density at large distances from the species' main range has been an issue of controversy, a subject of heated debate and a focus of intensive research for at least two decades. The traditional random walk/diffusion-based theoretical framework that predicts a thin Gaussian tail was eventually opposed by "superdiffusion" theories resulting in a fat tail with either exponential or even a slower power law rate of decay. Indeed, field data often show a decay rate slower than Gaussian. This issue is apparently very important for understanding invasion rates as a fatter tail normally results in a faster spread of the invading species. Here we show that the thin tail is, in fact, an artifact of an over-simplified description of the dispersing population and not an immanent property of the random walk diffusion. Specifically, we show that a fat-tailed dispersal curve arises naturally in a population of non-identical individuals, i.e. in a population with some inherent "statistical structure." Therefore, contrary to a widely spread opinion, a thick dispersal tail is not necessarily a fingerprint of Levy flights or superdiffusion.

A good understanding of population dispersal and biological invasions is hardly possible without knowing what happens on the microscale of the individual movement. Correspondingly, we then proceed to the analysis of animal's individual paths. Movement paths are characterized by the duration of bouts of continuous movements. Studies on different species have revealed that the distribution of bout durations often has a fat tail well described by a power law. The relation between this pattern and the underlying processes remains poorly understood though. Basing on the concept of "statistically structured population" introduced in the first part of the talk, here we formulate an approach that allows us to describe data on bout duration within a unified framework and show that a truncated fat-tail in the bout distribution of animal movement is an immediate consequence of the inherent statistical variation of individual traits.

Student Talks

Hypoellipticity of infinitely degenerate elliptic operators

by **Timur Akhunov**
University of Calgary

Elliptic differential equations are a natural generalization of the Laplace equation and are among the most studied differential equations. From an analytical perspective one of the most technically crucial properties for these equations is the regularity of their solutions. It has been established in 1930s through 60s that, for uniformly elliptic operators (which at every fixed point resemble a laplacian in a uniform way), solutions are 2 derivatives smoother than data in most Hoelder and Sobolev spaces. The weakest form of this property is called hypoellipticity, when a smooth data leads to smooth solutions, but the amount of gain (or loss) is not specified. In a landmark 1964 paper Lars Hormander established a bracket criterion for degenerate elliptic operators that gain a positive number of derivatives. In this talk, I will discuss a new class of examples of degenerate elliptic operators that gain no derivatives, based on the joint work with Cristian Rios.

Post-transplant Lymphoproliferative Disorders: Novel Risk Factors and a Mathematical Model

by **Michael Akinwumi**
University of Alberta

Post-transplant lymphoproliferative disorder (PTLD) encompasses a range of life-threatening diseases specific to transplant recipients. It has incidence rate of between 1% to 10% and 90% of PTLD is associated with Epstein-Barr virus (EBV) infection of B lymphocytes. It is estimated that 90% of human population are EBV carriers. The objective of my current research is to mathematically model three competing hypotheses for how EBV persists in normal humans. I will present preliminary results from statistical analysis of EBV data from our collaborators and also present a mathematical model for EBV persistence.

Inverse Galois Problem: Example of group of low degree

by **Francois Amalega**
University of Montreal

The question of whether all finite groups can occur as Galois group over the rationals (the inverse Galois problem) is still unsolved. In the talk, I want to make a survey of the problem. Presenting general results in one part and in the order, I want to focus on some groups of low dimension and on rigid groups.

Poincaré series map on open Riemann surfaces

by **Nadya Askaripour**
University of Calgary

Poincaré series is a classic technique to construct automorphic forms. Let R be a Riemann surface and $k > 1$ be an integer. Poincaré series produces a linear and bounded operator from $A^{(k)}(\Delta)$ (which is the space of holomorphic and integrable k-differentials on the unit disc) onto $A^{(k)}(R)$ (which is the space of holomorphic and integrable k-differentials on R). I will talk about some applications of Poincaré series on Riemann surfaces. Also I will talk about the kernel of Poincaré series map, specially I will talk about some results in this direction, obtained with T. Barron.

Bilateral Series and Ramanujan's Mock Theta Functions

by **Jitendra Bajpai**
University of Alberta

In his famous deathbed letter to Hardy in 1920, Ramanujan wrote down 17 curious q-series which he dubbed mock theta functions. Due to work of Zwegers in 2000, we are now able to recognize Ramanujan's mock theta functions as holomorphic parts of weight 1/2 harmonic weak Maass forms. Although this has been a catalyst for recent developments in numerous areas of mathematics. In my talk, I will focus on Ramanujan's original formulation. I will give a brief account of the modularity of bilateral series associated to mock theta functions and if time permits then I will talk about the Ramanujan's radial limits.

Hopf Invariant and LS-Category

by **Marzieh Bayeh**
University of Regina

Lusternik-Schnirelmann category (or simply LS-cat) is a measure of complexity of a topological space. It is a topological invariant defined to be the least integer n such that there exists an open covering set of $n + 1$ open sets with each open set contractible to a point in the whole space. In this talk we consider the relation between LS-cat and Hopf invariant of a kind constructed classically by Berstein, Hilton and Ganea.

A Historical Overview of the Turbulent Autoconversion Process in Droplet Size Evolution

by **David Collins**
University of Victoria

Global climate models need accurate representations of cloud droplet radii to adequately model (i) the amount of solar and terrestrial radiation reflected by cloud droplets and (ii) the time until the onset of precipitation. The spectrum of cloud droplet radii can span five orders of magnitude: from less than 1 micron to several millimetres. The rate at which liquid water is moved from the part of the spectrum where its motion is strongly influenced by local fluid motion (cloud droplets) to the part of the spectrum where it will precipitate (rain droplets) is dependent on the autoconversion process. Autoconversion parameterizations have failed to generate rainfall as quickly as is observed. Turbulence has been shown to increase the autoconversion rate and accelerate the onset of precipitation. Although turbulent autoconversion parameterizations are an improvement over non-turbulent ones, they still fail to adequately advect liquid water mass along the droplet spectrum. We present a historical overview of the development of autoconversion parameterizations, the inclusion of turbulence, and identify areas for further research.

HIV, Data, and Identifiability

by **Rebecca de Boer**
University of Alberta

Using data to find parameter values for mathematical models sounds reasonable and there are a number of different methods that can be used. I will discuss parameter fitting for a model of HIV using data from the Province of Alberta, and we will see what goes wrong when the parameters are not identifiable.

Useful Pointless Abstract Nonsense: A Handshake with Topoi

by **Yuri Delanghe**
University of Alberta

Topoi were originally introduced by Grothendieck as generalized spaces for use in algebraic geometry, and were later generalized by Lawvere and Tierney to become “generalized logical universes”. They have since been applied in a wide range of areas within and without mathematics, and more recently have been proposed as a unifying theory of mathematics by O. Caramello. In this talk we present an overview of the main notions of topos theory, and give a brief introduction to Caramello’s work.

Optimal Portfolio Versus No-arbitrage and Its Application

by **Jun Deng**

University of Alberta

Since the original work of Arrow and Debreu (1954), in the context of discrete market (i.e. finite scenarios and finite number of trading times), it has been proved that the utility maximization admits optimal solution if and only if there exists an equivalent martingale measure (called EMM hereafter) or equivalently there is no arbitrage. This result has been baptized as the classical fundamental theorem of utility maximization (called FTUM hereafter). However, this theorem in this current formulation fails in general continuous-time semi-martingale framework even with smooth enough utility function. In fact, there exist continuous time semimartingale models where the arbitrage opportunities and optimal portfolio both exist. In this paper, we investigate how far we can weaken the non-arbitrage condition as well as the utility maximization problem to preserve their complete and strong relationship described by the FTUM. As the first main contribution, we established the new version of fundamental theorem of utility maximization. Precisely, the equivalence between utility maximization and EMM is reformulated as a localized version by a stationary increasing stopping times and a weaker non-arbitrage concept called No-Unbounded-Profit-with-Bounded-Risk (called NUPBR hereafter).

As an important application of our new version of the FTUM, we established the equivalence between the NUPBR condition, the existence of numéraire portfolio, and the existence of solution to the utility maximization under change of equivalent probability measure. The latter fact can be interpreted as a sort of weak form of market's viability. Furthermore, the obtained equivalent probability measure can be chosen as close to the real-world probability measure as we want (but might not be equal).

This talk is based on the joint work with Choulli T. and Ma J.F.

On Benford's law in dynamical systems

by **Gideon Eshun**
University of Alberta

We apply the widespread logarithmic distribution of first significant digits and significands of numbers (referred to as *Benford's Law*) to dynamical systems. Using recent tools and conditions under which a recursively defined sequence is *Benford* via the classical theory of uniform distribution modulo 1, this study derives a generic condition ("*resonant spectrum*") under which a solution to a differential or difference equation is *Benford*.

Weighted Hardy-Littlewood-Sobolev Inequality on the unit sphere

by **Han Feng**
University of Alberta

In this talk, we will focus on the Hardy-Littlewood-Sobolev Inequality on the unit sphere S^{d-1} with the Jacobi weight h_κ, in terms of the orthogonal decomposition $L_2(h_\kappa; S^{d-1}) = \oplus_{j=0}^{\infty} H_j^d(h_\kappa)$. As we know HLS inequality plays a key role in the PDE theory in the Euclidean spaces. It is natural to believe that the inequality will also improve the development of PDE theory on the sphere. The main result we shall talk for the fractional integrals I_κ^α is a conditional one, guaranteeing the boundedness from L_p to L_q, for $1 < p < q \leq \infty$, and α is a suitable positive number. The fractional integrals one is interested in here are operators I_κ^α, expressible in the form $I_\kappa^\alpha f := \sum_{j=1}^{\infty} \lambda_j^{-\alpha/2} P_j f$, where λ_j is the eigenvalue of h-Laplace-Beltrami operator $\Delta_{\kappa,0}$ with respect to the eigenspace $H_j^d(h_\kappa)$ and P_j is the orthogonal projection on the space $H_j^d(h_\kappa)$. To understand the fractional integrals better, we find an effective decomposition for the h-Laplace-Beltrami operator $\Delta_{\kappa,0}$ with a family of differential and difference operators, which leads to a crucial estimate for $\left\|\Delta_{\kappa,0}^{1/2} f\right\|_{\kappa,p}$ and makes the HLS inequalitys application to be possible.

Detecting Algebraic Cycles through Height Pairing

by **Souvik Goswami**
University of Alberta

For an algebraic variety X, there is a functor $CH^\bullet(X)$ attached to it. The elements of $CH^\bullet(X)$ are called algebraic cycles. The name 'cycles' was perhaps motivated from the cohomology theory of X. There are several ways to detect non-zero cycles, one of them being height pairing. I am going to introduce the necessary definitions and if time permits, talk about an interesting direction.

On Barzilai and Borwein gradient method for large scale optimization problem

by **Yipin Guo**
University of British Columbia Okanagan

In this talk, I will discuss Raydan's globalization strategy for the Barzilai and Borwein method in unconstrained optimization. A strategy based on the nonmonotone line search technique is used to guarantee global convergence. Numerical results show that the global Barzilai and Borwein method requires less number of line searches and number of gradient evaluations compared with CONMIN and PR+ methods.

Explicit Formula for the Optimal Government Debt Ceiling

by **Ricardo Huaman**
University of Alberta

Motivated by the current debt crisis in the world, we develop a government debt control model to study the optimal debt ceiling. We consider a government that wants to control optimally its debt-to-GDP ratio. We assume that debt generates a cost for the country, and this cost is an increasing and convex function of the debt ratio. The government can intervene to reduce its debt ratio, but there is a cost generated by this reduction. The goal of the government is to find the optimal control that minimizes the expected total cost. We obtain an explicit solution for the government debt problem, that gives an explicit formula for the optimal debt ceiling, as a function of fundamental economic and financial variables. Moreover, we derive a practical rule for the optimal debt policy in terms of the optimal debt ceiling.

Applications of hybrid monte carlo methods to Bayesian logistic and t-probit models in genomic studies

by **Lai Jiang**
University of Saskatchewan

The efficiency of sampling from posterior distribution is important to bayesian models in high-throughput genomic tudies. Hybrid Monte Carlo (HMC) techniques employs auxiliary momentum variables to explore the phase space and update features jointly towards possible local modes, which is especially efficient for complicated target posterior distributions which may contain multiple modes. We apply hybrid monte carlo methods to bayesian logistic and t-probit models to speed up the Markov Chain convergence. Detailed results are presented for the comparison of different methods on gliomas data.

A spatial model with generalized logistic type growth and a carrying capacity driven diffusion

by **Md Kamrujjaman**
University of Calgary

The generalized logistic growth reaction-diffusion model is considered as follows

$$\begin{aligned}
\frac{\partial u(t,x,y)}{\partial t} =& D\left(\frac{u(t,x,y)}{M_1(x,y)}\right) + r(x,y)u\left(1-\frac{K_2(x,y)u-K_1(x,y)w+M_1(x,y)w}{K_2(x,y)M_1(x,y)}\right)\\
\frac{\partial w(t,x,y)}{\partial t} =& D\left(\frac{w(t,x,y)}{M_2(x,y)}\right) + r(x,y)w\left(1-\frac{K_1(x,y)w-K_2(x,y)u+M_2(x,y)u}{K_1(x,y)M_2(x,y)}\right)\\
\frac{\partial (u/M_1)}{\partial n} =& \frac{\partial (w/M_2)}{\partial n} = 0, \text{ on } (0,T]\times\partial\Omega\\
u(0,x) =& u_0(x),\ w(0,x)=w_0(x),\ x\in\Omega
\end{aligned}$$

We investigate the preceding reaction-diffusion system theoretically as well as numerically for existence, positivity, persistence, extinction and stability of solutions. The system without diffusion is an unstructured model which is analyzed locally.

SYZ conjecture on Calabi–Yau threefolds of type K

by **Atsushi Kanazawa**
University of British Columbia

Calabi–Yau threefolds are higher dimensional analogue of elliptic curves and K3 surfaces. In 1996 Strominger, Yau and Zaslow conjectured some duality among Calabi–Yau threefolds. In this talk, I will describe this duality for elliptic curves, K3 surfaces and Calabi–Yau threefolds of type K.

Heegner Points: A marriage of algebra, analysis and geometry

by **Jordan Kostiuk**
University of Alberta

The most elegant results in mathematics are those that are forged in the inter-section of many different areas. A brilliant example of this is the theory of Heegner points, which are special points appearing in the moduli space of elliptic curves. I will explain how the invention of these points has shed light on two famous problems in number theory: the first being Hilbert's twelfth, which asks us to explicitly construct class fields of algebraic extensions, and the second being the Birch and Swinnerton-Dyer conjecture which, among other things, states that arithmetic properties of an elliptic curve are intimately related to the analytic properties of its L-function.

The game of basic mancala

by **Maximilano Liprandi**
University of Calgary

Mancala is the name for a family of "sowing" games played in many regions of the world. One of its versions, Kalah, is played on a board that consists of two rows of six holes or pits, as well as two stores, one to each side of the rows. Here, the game starts with m seeds in each pit. A move in the game is to "sow" the seeds from one of the pits. In the end, the player with the most seeds in his store wins the game. Based on this game, we can design a combinatorial version of it, with similar mechanics, but a different winning condition: the player to make the last available move is the winner. We call this game BASIC MANCALA. At the start of the game there are m seeds in each of the $2n$ pits. The cases $n = 1$ and 2 are games which are of interest in both the partizan and impartial (both players have access to either side of the board) versions.

Jointpoint Regression Estimation using LASSO Variable Selection

by **Matus Maciak**
University of Alberta

Jointpoint regression models become popular in recent years, especially in modeling various trends in different areas, like economics, mortality and incidence series, or epidemiology studies and clinical trials. This is mainly due to their very simple interpretation, which reduces to interpreting a set of simple linear lines over a sequence of non-overlapping but joint segments, where in addition a continuity condition is always postulated.

Classical approaches to the jointpoint regression estimation involve an L_2-norm based minimization with a model selection step being performed using either some permutation tests or the Bayesian inference instead. In our approach however, we introduce the LASSO penalty and using a sparsity principle we propose an automatic and fully data-driven method as a convenient alternative to existing methods. The main statistical properties are derived and proved, and finite sample properties are under investigation using a simulations study and some real data examples.

An Introduction to Lattices And Their Applications

by **Rebecca Meissen**
University of Calgary

Lattices are discrete subgroups of $\mathbb{R}^n$ whose members are formed by integer combinations of a set of basis vectors. They are equipped with a symmetric bilinear form which describes the relative distance between two members. Despite the simplicity of their construction, lattices have powerful applications in both industry (cryptography, combinatorial optimization) and academia (algebraic number theory). In this talk, we will introduce some of the core concepts behind lattices and their properties. We will then examine several computationally complex problems arising from lattices. Finally, if time permits we will explore some newer applications and methods.

TBA

by **Stefan Mendez-Diez**
University of Alberta

TBA.

A mathematical investigation of plasma membrane heterogeneity

by **Rochelle Nieuwenhuis**
University of Alberta

The plasma membrane is fundamental for the cell's ability to communicate with its surroundings, and in particular, integral membrane proteins are required to receive and transmit signals across the membrane. The organization of these proteins can heavily influence their function, thus a solid understanding of the plasma membrane structure is needed. Membrane heterogeneity may be due to structures such as lipid rafts, corrals, confinement zones, and interactions with the cytoskeleton, however, these can be difficult to characterize and mathematical analyses and models can be valuable tools. I will present two mathematical approaches to investigating membrane heterogeneity. The first addresses the question of protein clustering and the association of these clusters with lipid rafts. As lipid rafts are smaller than the resolution limit of a light microscope, super-resolution microscopy is employed to visualize each protein in a population of proteins at one fixed time point. Ripley's K function provides a means for calculating average cluster radii. We proposed that Ripey's K function can also be applied to two populations of proteins simultaneously to measure the extent to which they colocalize. This could provide a reliable method for determining whether a protein of interest is associated with lipid rafts. This approach was successful on simulated protein populations, but was not consistent when applied to experimental data, possibly due to experimental errors. The second approach addresses the question of confinement zones, and looks at the characteristic movement of an individual protein in the population, rather than the relative positions of all members of the population. Here we record the movement trajectory of individual proteins over time and test for the presence of transient confinement zones using First Passage Time. Calculating the variance in First Passage Time gives a measure of the confinement zone radius. While these two approaches seem to deal with different structural components, the presence of transient confinement zones may coincide with protein association with lipid rafts. Future research should apply these two approaches to the same protein population in order to obtain a conclusive comparison.

Deriving space use patterns from animal interaction mechanisms

by **Jonathan Potts**
University of Alberta

Deriving animal space use patterns from their interactions with each other and the environment is vital for predicting the effects of environmental and population changes on the local viability of species. Here, we present a general framework for determining the nature of animal-habitat and animal-animal interaction mechanisms, that integrates naturally with their underlying movement processes. It is based around the notion of a step-selection function (SSF), recently introduced into the literature to determine how animal movement choices are influenced by their surrounding environment. We show how this framework can be extended to derive the utilisation distribution of animals, and how small changes in the construction of the SSF can lead to qualitatively different space use patterns. We further extend the framework to include inter-animal interactions, which may either be direct or mediated by stigmergent processes. We demonstrate the efficacy of our approach by application to two distinct populations: Newfoundland caribou herds and Amazonian insectivore bird flocks.

This work is in collaboration with Guillaume Bastille-Rousseau, Mark A. Lewis, Karl Mokross, Dennis L. Murray, James A. Schaefer and Philip C. Stouffer.

Google's PageRank for Analyzing Metabolic Networks

by **Shi Qiu**
University of Saskatchewan

Internet technique can solve biological problem. For the large network emerged in protein interaction network databases, the problem of finding important nodes can be solved by PageRank algorithm. A rank of webpages is called PageRank. PageRank algorithm is an algorithm to solve PageRank for particular web network. PageRank algorithm is originally to compute the order of web pages with in World Wide Web graph. The most successful PageRank algorithm was developed by Page and Brin and used in Googles search engine. With the property of stability and robust, PageRank technique is attractive in application biological networks.

Bayesian Inference for Gene Networks

by **Abdollah Safari**
Simon Fraser University

There are several methods for inference in gene networks, but there are few cases in which historical information has been considered. Our approach implements a Bayesian model that utilizes available information. Our model, which assumes a proper prior distribution, is an improvement over standard methods as it takes the dependency of parameters into account. We compare the results obtained from (1) method of moment estimation and (2) combining prior information and samples to estimate hyper parameters. A simulation based on Gibbs samplers was used to compare the results. We will also discuss the strengths and weaknesses of each method.

This talk is based on joint work with A. Sharifi, H. Pezeshk, M. Sadeghi, C. Eslahchi.

On equivariant cobordism of torus orbifolds

by **Soumen Sarkar**
University of Regina

We introduce generalized weighted projective spaces. We show that any torus orbifold with locally standard torus action is equivariantly cobordant to some copies of generalized weighted projective spaces. Moreover, if the torus action has no fixed point then it is equivariantly boundary.

Can we hear the shape of a drum?

by **Mark Sebestyen**
University of Alberta

An appetizer into the sonorous world of geometrical lattices and their modular forms.

Double Exponential Sinc-Collocation Methods for Computing Energy Levels of the Schrodinger Equation with Anharmonic Potentials

by **Richard Slevinsky**
University of Alberta

Computing energy levels of the Schrodinger equation is a research area that has seen contributions from many researchers over the years. The most fundamental potentials, from a mathematical perspective, have been an harmonic oscillators defined by the Hamiltonian: $\mathcal{H} = -\frac{\mathrm{d}^2}{\mathrm{d}x^2} + V(x)$, where the potential $V(x) = \sum_{i=1}^{m} c_i x^{2i}$ with $c_m > 0$. Using the double exponential Sinc-collocation method (DESCM), we develop a highly efficient and accurate algorithm for computing energy eigenvalues of this Hamiltonian. A method for finding the optimal step size given the number of collocation points $2N+1$, is also introduced. This method is based on asymptotic representation of the derivative of the trace of the matrix obtained through the DESCM. Numerical examples with an array of different values for the coefficients c_i, $1 \leq i \leq m$, demonstrate the linear convergence of the DESCM for the eigenvalues and eigenfunctions.

Khinchine inequality for slightly dependent random variables

by **Susanna Spektor**
University of Alberta

I will discuss different techniques of proving a Khinchine inequality. In particular, I will prove a Khintchine type inequality under the assumption that the sum of Rademacher random variables equals zero.

Prediction of HIV prevalence in China

by **Zhimin Su**
University of Alberta

A SIDT model based on ordinary differential equations has been built to understand the HIV disease dynamics in China. Since a model that characterizes the essential disease dynamics can be used for prediction only if the model parameters are identifiable from data, Bayesian method is applied to estimate our model parameter values. Afterwards the obtained posterior estimation for each parameter is used to predict the HIV prevalence in China. In the end our model is validated by the matching between model prediction and the real data from Yunnan province in China.

Modeling Brain Tumour Spread Using Anisotropic Diffusion

by **Amanda Swan**
University of Alberta

Many biological processes can be modeled using diffusion, and brain tumours are no exception. This talk will discuss the process by which the spread of a brain tumour can be modeled using diffusion. Our diffusive models are anisotropic, or directed, due to the heterogeneous nature of the brain, and since it has been shown that cancer cells prefer to move along white matter tracts. I will discuss a simple PDE model for this process, as well as several numerical techniques for simulating the spread.

Hypergroups and projections

by **Nazanin Tahmasebi**
University of Alberta

An algebraic hypergroup represents a set together with a multi-valued associative binary operation satisfying certain conditions. This definition defines a purely algebraic object, however, hypergroups appear in analysis, in particular, in the study of the dual object of a compact group, the double coset space of a locally compact group by a compact subgroup and the space of conjugacy classes of a locally compact group. Therefore, it was natural for analysts to seek an appropriate definition to be used in harmonic analysis. A good structure was made simultaneously in the 1970's by Dunkl, Jewett and Spector. A hypergroup is a locally compact Hausdorff space, K, with a convolution defined on $M(K)$. The major difference between groups and hypergroups is that in hypergroups $\delta_x * \delta_y$ is a probability measure with compact support and need not be a point mass measure for $x, y \in K$.

Let K be a hyprergroup with a Haar measure. In this talk we construct a one-to-one correspondence between compact sub-hypergroups and specific subclass of the class of left translation invariant C^*-

subalgebras of $C_0(K)$ (the space of all continuous bounded functions on K which vanish at infinity). By the help of this characterization, then we extract some results concerning invariantly complemented subspaces of $C_0(K)$. We also characterize amenability of K in terms of complemented subspaces of $LUC(K)$. We note that as one changes the underlying space to a locally compact group, this characterization is equivalent to saying that X is invariantly complemented in $LUC(K)$, where $LUC(K)$ is the space of bounded left uniformly continuous complex-valued functions on K.

A short introduction to John's theorem, with applications

by **Steven Taschuk**
University of Alberta

John's theorem (1948) characterizes the maximum volume ellipsoid in a convex body in terms of the contact points between the two. We will state this characterization, interpret it, and demonstrate two applications to estimating Banach–Mazur distances: John's classical estimate for distance to the Euclidean ball, and an improvement of an idea of Lassak (1991) estimating distance to the cube.

A Phage-Bacteria Petri Dish Model in Different Types of Media: Nutrient-Limited Growth, Movement, and Predation

by **Silogini Thanarajah**
University of Alberta

Mathematical modeling plays an important role in microbiology because it provides a pivotal link between the concepts and the different aspects of the real world problems, their interaction, and dynamics. To study the role of bacteriophages in controlling the densities of bacterial population, we consider the spread and interaction of bacteria and phage in a petri dish. We construct a group of bacteria-bacteriophage petri dish model using PDEs. Furthermore, we present some mathematical and numerical results of this model, such as steady states, traveling wave solutions, and asymptotic behavior of solutions.

Class Numbers and Continued Fraction Expansions

by **Michael Wanless**
University of Calgary

D. Zagier proved an interesting result that provides an explicit formula for the class number of $\mathbb{Q}(\sqrt{-p})$ given certain conditions on p and $\mathbb{Q}(\sqrt{p})$. Remarkably, this formula is based almost entirely on the negative continued fraction expansion of $\sqrt{p}$. It turns out that this result is actually just a special case of a more

general, but much more abstract theorem. We will explore this general theorem and discuss other concrete versions for families of non-prime radicands.

Finite convergence of subgradient projection method

by **Jia Xu**
University of British Columbia Okanagan

We are interested in solving the convex feasibility problem, which asks to find a solution to a convex inequality. One popular approach to this problem is to employ Polyak's subgradient projection method. However, it may converge slowly even when a Slater point is present.

In my research, I have started to work on unifying some approaches to accelerate convergence based on works by Crombez, by Polyak and by Censor. In my talk, I will outline the main ideas and present some encouraging results and examples.

Isoperimetric Inequalities for k-Hessian Capacity

by **Ning Zhang**
Memorial University of Newfoundland

In the ancient Carthage, the founder and first Queen, Dido, asked for a region of maximal area bounded by a straight line and a curvilinear arc whose endpoints belong to that line. A closed related question mentioned in ancient Greece asked for the maximal region with the perimeter of a certain length, which is well-known as the isoperimetric inequality. In this talk, we firstly introduce a special capacity from k-Hessian equation. Then, we discover that the isoperimetric inequalities for k-Hessian capacity are exactly the geometrical capacitary forms of Chou-Wang's Sobolev type inequality and Tian-Wang's Moser-Trudinger type inequality for the Hessian operators.

Application of Hawkes process to historical data

by **Boyko Zlatev**
University of Alberta

In the talk different statistical models are applied to time series of ancient and medieval historical data - number of battles per year, changes of rulers, etc. Among the models considered are Poisson process, autoregressive Poisson and Hawkes process. The latter is shown to give the best fit (according to AIC) for some of the datasets. Some methodological aspects of estimating the parameters of Hawkes process for this kind of date are also briefly discussed.

Direction-dependent communication in a Lagrangian model of collective behaviour

by **Cole Zmurchok**
University of Alberta

Many mathematical models of self-organizing collectives use partial differential equations (PDE) to describe the dynamics of the density of individuals throughout space. Opposite these PDE models are the individual-based models that describe the movement of each individual. In both modeling approaches, social interaction forces describe how individuals interact and move, and spatiotemporal group formation patterns are a consequence of these distance-dependent social interaction forces. The Eftimie model is a one-dimensional nonlocal hyperbolic model that introduces direction-dependent communication mechanisms. Implementation of a variety of communication mechanisms produces group formation patterns that have not been observed in other models. In this presentation, I will re-formulate the Eftimie model as an individual-based model, allowing for the social interaction forces to be easily described in terms of nearby neighbors. The individual-based model produces results identical to the original model throughout parameter space, up to stochastic effects. Discretizing the Eftimie model demonstrates that direction-dependent communication likely plays an important role in producing complex group formation patterns with individual-based models.