CANADIAN OPERATOR SYMPOSIUM 2018
TITLES AND ABSTRACTS

Mini-lecture series

David Kribs (University of Guelph). *Quantum Information: A brief (and a little self-indulgent) mathematical introduction*

I'll begin this lecture series with a general introductory quantum information talk in which I'll hit on as many subtopics that I can jam into one talk, briefly touching on the underlying mathematics in each case. The next two talks will focus on a (somewhat self-indulgent) selection of topics in quantum information that involve aspects of operator theory and operator algebras.

Orr Shalit (Technion). *Noncommutative function theory on noncommutative varieties, noncommutative convex sets, and their connections to operator theory*

This series of lectures is about certain "noncommutative sets" and "noncommutative functions" — in particular: noncommutative (nc) subvarieties of the nc unit ball, nc holomorphic functions, and nc convex sets — which have recently been used in the solution of problems in operator theory, operator algebras, and elsewhere.

– I will begin by introducing noncommutative (nc) holomorphic functions in several nc variables. There are several takes on the subject, and I will present the version that I believe is the simplest and most attractive, which was developed by Kalyuzhni-Verbovetskii and Vinninkov, Agler and McCarthy, Helton, Klep and McCullough, and others.

  Roughly speaking, a *nc holomorphic function* in d noncommuting (complex) variables, is a certain well behaved function that is defined on d-tuples of $n \times n$ matrices, where the size n is allowed to vary. For example, a polynomial $p(x_1, \ldots, x_d)$ in d free noncommuting variables is a nc holomorphic function: given a d-tuple $X = (X_1, \ldots, X_d) \in M_n^d$, one simply plugs the matrix X_i in the place of the variable x_i and gets a well defined $n \times n$ matrix $p(X_1, \ldots, X_d)$. Similarly, power series in free variables are nc holomorphic in their domain of convergence.

  The theory of nc holomorphic functions has some useful parallel lines, as well as some striking differences, with classical function theory in one or several variables. This field is now exploding with activity.

  After setting things up and surveying some basic results in nc function theory, I will explain how certain operator algebras that people have been interested in in the last decade or so, turn out to be algebras of bounded nc holomorphic functions on nc holomorphic varieties. Viewing these operator algebras as "nc-function algebras" opens new routes by which to approach the classification problem of these algebras.

– This lecture starts off where the previous one ended: the classification problem of certain non-selfadjoint operator algebras.

  Let V be a nc variety in the nc unit ball B_d. We write $H^\infty(V)$ for the algebra of bounded nc holomorphic functions on V. In this lecture we ask (and partially answer) the question: *to what extent does the structure of $H^\infty(V)$ encode the geometry of V, and vice-versa?*

  For the problem of classifying the algebras up to completely isometric isomorphism we have a complete solution: $H^\infty(V)$ and $H^\infty(W)$ are completely isometrically isomorphic if and only if V and W are conformally equivalent. The classification problem up to bounded or completely bounded isomorphism involves interesting subtleties: the geometric object that encodes the structure of $H^\infty(V)$ is now not V but its *similarity envelope* $\widetilde{V}$. I will present some results as well as open problems.

The second lecture is based on works (mostly joint) of Guy Salomon, Eli Shamovich, and myself.

– In the third lecture we leave the noncommutative version of complex analysis, and we shift our focus to a noncommutative version of (real) convex analysis.

Let $(M_n^{sa})^d$ be the set of all d-tuples of selfadjoint $n \times n$ matrices. A *matrix convex set* is a subset $S \subseteq \sqcup_n (M_n^{sa})^d$ of the set of all d-tuples of self-adjoints, that is invariant under *matrix convex combinations*. Every matrix convex set S has a *ground level* $S_1 = S \cap (M_1^{sa})^d = S \cap \mathbb{R}^d$, that consists of all the scalar d-tuples in S. The ground level of a matrix convex set is always a convex set in $\mathbb{R}^d$.

A central problem of interest is to understand when is the matrix convex set S contained in another matrix convex set T, and in particular when are two matrix convex sets equal. For example, it might be that the gound levels S_1 and T_1 of S and T are equal; does this mean that S and T are equal? In general, the answer is no. Is there anything that can be said?

In order to approach this problem, we introduced the minimal and the maximal matrix covex sets "over" a convex set $K \subseteq \mathbb{R}^d$; that is, the minimal and maximal matrix convex sets that have K as their ground level. These sets are denoted $W^{min}(K)$ and $W^{max}(K)$, respectively. We prove that $W^{min}(K) = W^{max}(K)$ if and only if K is a simplex. Moreover, for a class of convex bodies we find the optimal constant $\theta(K)$ that satisfies

$$W^{max}(K) \subseteq \theta(K) \cdot W^{min}(K).$$

For example, we find that $\theta(\overline{\mathbb{B}}_{d,p}) = d^{1-|1/p-1/2|}$ (here $\overline{\mathbb{B}}_{d,p}$ is the closed unit ball of $\mathbb{R}^d$ equipped with the p-norm).

These containment problems turn out to be related to operator theory in several ways. First, they can be used to approach the UCP interpolation problem, which is: *given operators $A_1, \ldots, A_d$ and $B_1, \ldots, B_d$, decide whether there exists a unital completely positive map ψ such that $\psi(A_i) = B_i$ for every i.* This means that matrix convex sets encode the information contained in finite dimensional operator systems. In addition, every containment of the form $W^{max}(K) \subseteq W^{min}(L)$ gives rise to a new dilation theorem. For example, the inclusion $W^{max}(\overline{\mathbb{B}}_{d,\infty}) \subseteq \sqrt{d} \cdot W^{min}(\overline{\mathbb{B}}_{d,\infty})$ is equivalent to the following dilation theorem: *every d-tuple of self-adjoint contractions can be dilated to a d-tuple of commuting self-adjoint contractions, each having norm at most $\sqrt{d}$.*

The third lecture is based primarily on works of Ken Davidson, Adam Dor-On, Ben Passer, Baruch Solel, and myself (in various combinations).

Aaron Tikuisis (University of Ottawa). *Structure and regularity for C*-algebras: nuclear dimension, $\mathcal{Z}$-stability, and classification*

Regularity properties for C*-algebras is a subject that arose in the context of the Elliott classification programme: an attempt to classify all simple separable nuclear C^*-algebras by K-theoretic invariants. This classification programme hit a serious stumbling block due to examples by Villadsen and their refinements by Rordam and Toms. Regularity properties for C^*-algebras are a reaction to this stumbling block: they were an attempt to separate the C^*-algebras for which classification might be reasonable from the ones for which classification should fail.

I will introduce and elucidate these regularity properties: nuclear dimension, $\mathcal{Z}$-stability, and (with less focus) Cuntz semigroup regularity. We will see the Toms-Winter conjecture, which predicted the equivalence of these properties among simple separable infinite-dimensional unital nuclear C^*-algebras. Most parts of this conjecture have been confirmed, and I will discuss some of the key techniques that have gone into this, and in particular, the rich connection to von Neumann algebraic techniques.

Plenary lectures

Ionut Chifan (University of Iowa). *Rigidity in group von Neumann algebras*

In the mid thirties F. J. Murray and J. von Neumann found a natural way to associate a von Neumann algebra $L(G)$ to every countable discrete group G. Classifying $L(G)$ in terms of G emerged from the beginning as a natural yet quite challenging problem as these algebras tend to have very limited "memory" of the underlying group. This is perhaps best illustrated by Connes' famous result asserting that all icc amenable groups give rise to isomorphic von Neumann algebras; thus in this case, besides amenability, the algebra has no recollection of the usual group invariants like torsion, rank, or generators and relations. In the non-amenable case the situation is radically different; many examples where the von Neumann algebraic structure is sensitive to various algebraic group properties have been discovered via Popa's deformation/rigidity theory. In this talk I will present several new instances where the von Neumann algebra completely retains canonical algebraic constructions in group group theory such us (infinite) direct product, amalgamated free product, or wreath product. In addition, I will present several applications of these results to the study of rigidity in the C*-setting.

Elizabeth Gillaspy (University of Montana). *Generalized gauge actions, KMS states, and Hausdorff dimension for higher-rank graphs*

The infinite path space Λ^∞ of a higher-rank graph Λ is (often) a Cantor set – compact, perfect, totally disconnected. Together with Carla Farsi, Sooran Kang, Nadia Larsen, and Judith Packer, we have found several ways to put a metric on this Cantor set, and computed the associated Hausdorff dimension and measure. It turns out that the same data we needed to metrize Λ^∞ also gives us a generalized gauge action on $C^*(\Lambda)$ – and the KMS states associated to this action are intimately tied to the Hausdorff measure on Λ^∞. To us, this was an unexpected link between the dynamical information exhibited by a higher-rank graph (as exhibited in its KMS states) and its fractal structure.

All the words in the title will be defined during the talk; no prior familiarity with higher-rank graphs, KMS states, or Hausdorff dimension will be assumed.

Pamela Gorkin (Bucknell University). *The numerical range and compressions of the shift operator*

After a brief introduction to the numerical range of a matrix and some applications, we discuss some standard techniques used to study it. We then apply these to obtain properties of the numerical ranges of compressions of the shift operator in various settings.

Bradd Hart (McMaster University). *Model theory of correspondences*

I will discuss the model theoretic understanding of Hilbert bimodules. In particular I will introduce the notion of ultraproducts of bimodules and show that for fixed tracial von Neumann algebras, the class of Hilbert bimodules forms an elementary class. With this background ii is possible to understand property T as statement about definable sets. This is joint work with Isaac Goldbring and Thomas Sinclair.

Michael Hartz (Washington University in St.Louis). *Interpolating sequences and Kadison-Singer*

A sequence (z_n) in the unit disc is called an interpolating sequence if for every bounded sequence of values (w_n), there exists a bounded analytic function f in the disc such that $f(z_n) = w_n$ for all n. Such sequences were characterized by Lennart Carleson.

I will talk about a generalization of Carleson's theorem to other classes of functions, namely multiplier algebras of complete Pick spaces. The proof of this result uses the solution of the Kadison-Singer problem due to Marcus, Spielman and Srivastava. This is joint work with Alexandru Aleman, John McCarthy and Stefan Richter.

Astrid an Huef (Victoria University of Wellington). *Amenability of quasi-lattice ordered groups*

Let G be a discrete group with a generating submonoid P such that $P \cap P^{-1} = \{e\}$. There is a partial order on G defined by $x \leq y$ if and only if $x^{-1}y \in P$. The pair (G, P) is quasi-lattice ordered if all pairs of elements of G with a common upper bound in P have a least upper bound in P.

Quasi-lattice ordered groups and their Toeplitz algebras were introduced by Nica in 1992. A quasi-lattice ordered group is amenable if the concrete Toeplitz algebra, which is a subalgebra of the bounded linear operators on $l^2(P)$, is isomorphic to the C^*-algebra universal for certain representations of (G, P). For example, the Baumslag-Solitar group

$$G = \langle a, b : ab^c = b^d a \rangle$$

with submonoid P generated by a and b is an amenable quasi-lattice ordered group. Motivated by what happens for the Baumslag-Solitar group, I will discuss two sufficient conditions for amenability of a quasi-lattice ordered group.

Elias Katsoulis (East Carolina University). *Tensor algebras of product systems and their C^*-envelopes*

Let (G, P) be an abelian, lattice ordered group and let X be a compactly aligned, $\tilde{\varphi}$-injective product system over P. We show that the C^*-envelope of the Nica tensor algebra $\mathcal{NT}_X^+$ is the Cuntz-Nica-Pimsner algebra $\mathcal{NO}_X$ as defined by Sims and Yeend. We give several applications of this result, including applications to the Hao-Ng isomorphism problem and the existence of a co-universal C^*-algebra for injective, gauge compatible, Nica-covariant representations of product systems. (Joint work with Adam Dor-On.)

Matthias Neufang (Carleton University and Université Lille 1). *Topological Centres, Module Maps, and Invariant Means*

We present an overview of some of our work on topological centres associated with Banach algebras, and group actions. We shall also discuss related topics such as the structure of module maps on the dual of a Banach algebra A, and invariant means. Our results include solutions to several problems raised in the literature:

- Csiszár's conjecture (1971) on the topological centre of $LUC(G)^*$ for general topological groups (solved for all separable G, jointly with Ferri);
- the question raised by Ljeskovac-Sinclair (1981) of characterizing those C^*-algebras whose projective tensor square is Arens regular;
- the Ghahramani–Lau conjecture (1994/95) on the topological centre of the bidual of the measure algebra (jointly with Losert–Pachl–Steprāns);
- questions of Lau–Ülger (1996, 2014) on the structure of module maps on A^* stemming from topological centre elements (jointly with Hu–Ruan), and of natural and invariant projections on A^*;
- a question of Dales (2007) on small sets which are dtc, i.e., determining for the topological centre (jointly with Ferri–Pachl);
- the Farhadi–Ghahramani multiplier problem (2007);
- questions of Dales–Lau–Strauss and Daws (2011/12) on topological invariant means on weakly almost periodic functionals.

Christopher Schafhauser (University of Waterloo). *Subalgebras of AF-algebras*

A long-standing open question, formalized by Blackadar and Kirchberg in the mid 90's, asks for an abstract characterization of C*-subalgebras of AF-algebras. I will discuss some recent progress on this question: every separable, exact C*-algebra which satisfies the UCT and admits a faithful, amenable trace embeds into an AF-algebra. Moreover, the AF-algebra may be chosen to be simple and unital with unique trace and the embedding may be taken to be trace-preserving. Modulo the UCT, this characterizes C*-subalgebras of simple, unital AF-algebras. As an application, for any countable, discrete, amenable group G, the reduced C*-algebra of G embeds into a UHF-algebra.

Paul Skoufranis (York University). *Bi-Free Versions of Entropy*

In a series of papers, Voiculescu generalized the notions of entropy and Fisher information to the free probability setting. In particular, the notions of free entropy have several applications in the theory of von Neumann algebras and free probability such as demonstrating certain von Neumann algebras do not have property Gamma, demonstrating the absence of atoms in the distributions of polynomials of random matrices, and the construction of free monotone transport. With the recent bi-free extension of free probability being sufficiently developed, it is natural to ask whether there are bi-free extensions of Voiculescu's notions of free entropy. In this talk, we will provide an introduction to the notions of free entropy, discuss bi-free versions of entropy, and discuss the difficulties and peculiarities that occur in bi-free entropy theory. This is joint work with Ian Charlesworth.

Karen Strung (Institute for Mathematics, Astrophysics and Particle Physics at Radboud Universiteit). *Unitary orbits via transportation theory*

Results from the Elliott classification programme can be used to translate theorems of optimal transport into calculations of the distance between unitary orbits of normal elements in well-behaved C^*-algebras. In particular, in certain simple Jiang–Su stable C^*-algebras with real rank zero and trivial K_1, the distance between full-spectrum unitaries can be computed in terms of spectral data. This talk is based on joint work with Bhishan Jacelon and Alessandro Vignati.

Michael Whittaker (University of Glasgow). *Self-similar groups and their generalisations*

A self-similar group (G, X) consists of a group G along with a faithful self-similar action of the group on a rooted tree. Self-similarity is displayed by the action of the group acting on all levels of the tree, in a similar fashion to fractals where patterns are repeated at all scales. I will introduce self-similar groups and a generalisation to self-similar groupoids acting on the path space of a graph. Then I will show how to construct C^*-algebras associated to self similar actions and their KMS equilibrium states. This is joint work with Marcelo Laca, Iain Raeburn, and Jacqui Ramagge.

Contributed talks

Angel Barría Comicheo (University of Manitoba). *Elements of an operator theory on the space c_0 over a non-Archimedean valued field (Part I)*

In this talk we will discuss some aspects of operator theory on the space c_0 of null sequences in a non-Archimedean valued field of rank 1. A characterization of the closed subspaces that admit a normal complement is given, and their relation with normal projections is explained. Descriptions of compact operators and operators that admit an adjoint on c_0 are presented. Also, the operators that satisfy the spectral theorem can be expressed as a convergent series of normal projections, in which the coefficients allow a clear identification of the compact operators among the members of this family.

Ievgen Bilokopytov (University of Manitoba). *Continuity and Holomorphicity of Symbols of Weighted Composition Operators*

The following problem is considered: if $\mathbf{F}$ and $\mathbf{E}$ are (general) Banach spaces of continuous functions over locally compact spaces X and Y respectively, and $\omega : Y \to \mathbb{C}$ and $\Phi : Y \to X$ are such that the weighted composition operator $W_{\Phi,\omega}$ is continuous, when can we guarantee that both ω and Φ are continuous? An analogous problem is also considered in the context of Banach spaces of holomorphic functions. Some counterexamples will be constructed using the theory of reproducing kernel Hilbert spaces.

Zack Cramer (University of Waterloo). *Matrix Algebras with a Certain Compression Property*

A subalgebra $\mathcal{A}$ of $\mathbb{M}_n(\mathbb{C})$ is said to have the *idempotent compression property* if $E\mathcal{A}E$ is an algebra for all idempotents E in $\mathbb{M}_n(\mathbb{C})$. In joint work with Laurent Marcoux and Heydar Radjavi, a complete characterization of these algebras is obtained up to similarity. In addition, we investigate the analogous *projection compression property* and show that these two notions frequently coincide.

Luiz Gustavo Cordeiro (University of Ottawa). *Recovering locally compact spaces from disjointness relations on function algebras*

Several recovery theorems have been proven throughout the last century, mostly initiated and motivated by the work of Stone in the 30s, who proved that one can always recover a zero-dimensional compact Hausdorff space from its lattice of 0,1-valued functions. Generalizations and modifications abound, by considering different codomains with different algebraic structures. In this talk I will introduce notions of “disjointness” for functions with values in arbitrary Hausdorff spaces, and prove that, up to regularity conditions, one can always recover the domain space from these classes of functions. Several known - as well as some new - recovery theorems follows as consequence, and in particular, we obtain a classification of diagonal-preserving isomorphisms between certain groupoid algebras.

Adam Dor On (Technion). *Operator algebras for higher rank analysis and their application to factorial languages*

An effective model for encoding multivariable $\mathbb{Z}_+^N$-dynamical systems via C*-correspondences is given by the Toeplitz-Nica-Pimsner algebras introduced by Fowler. In the work of Carlsen, Larsen, Sims and Vitadello, a minimal “Cuntz-Nica-Pimsner” algebra that retains the dynamics is shown to exist. However in general, the precise relations between generators are rather difficult to ascertain.

In this talk based on joint work with Kakariadis, we introduce a new class of product systems over $\mathbb{N}^d$ that yield tractable relations for associated Cuntz-Nica-Pimsner algebras. We showcase our new relations in concrete examples such as higher rank graphs, $\mathbb{Z}_+^N$ C*-dynamical systems and higher-rank factorial languages. We conduct a case study of the C*-algebras associated to higher-rank factorial languages, showing that many rank-one results of Matsumoto, Carlsen, and of Kakariadis–Shalit have analogues in the higher-rank world.

Cristian Ivanescu (MacEwan University). *The Cuntz semigroup and classification theory*

An important class of C*-algebras (that announced by George Elliott in early 1990s) has been recently classified by means of K-theory. This class is referred to as the class of $\mathcal{Z}$-stable C*-algebras. However examples of C*-algebras have been shown to exist outside of this class, requiring an enlargement of the Elliott invariant. There is evidence that the Cuntz semigroup is useful in the classification theory. In this talk I will discuss the Cuntz semigroup as an invariant for C*-algebras and its applications to the classification theory.

Rupert Levene (University College Dublin). *Complexity and capacity bounds for quantum channels*

Any operator system $\mathcal{S}$ in $M_n(\mathbb{C})$ is the non-commutative confusability graph of some quantum channel. We introduce the "quantum complexity" of $\mathcal{S}$ as the smallest possible output dimension of such a quantum channel, and show that this generalises the minimum semidefinite rank of a classical graph. The quantum complexity and a closely related quantum version of orthogonal rank turn out to be upper bounds for the Shannon zero-error capacity of a quantum channel, and we show by example that these bounds can beat the best previously known general upper bound for the capacity of quantum channels, given by the quantum Lovász theta number.

This is joint work with Vern Paulsen (Waterloo) and Ivan Todorov (Belfast).

Boyu Li (University of Waterloo). *Regular Dilation and Nica-covariant Representation on Right LCM Semigroups*

Regular dilation has recently been extended to graph product of $\mathbb{N}$, where having a *-regular dilation is equivalent to having a minimal isometric Nica-covariant dilation. In this talk, we first extend the result to right LCM semigroups, and establish a similar equivalence among *-regular dilation, minimal isometric Nica-covariant dilation, and a Brehmer-type condition. This result can be applied to various semigroups to establish conditions for *-regular dilation.

Terry Loring (University of New Mexico). *Multivariate pseudospectrum and topological physics*

The usual pseudospectrum acquires an additional feature when restricted to matrices with a certain symmetry. The new feature is a simple form of K-theory which can be used to compute the index of some one-dimensional topological insulators. The usual pseudospectrum applies to a single matrix, or equivalently to two Hermitian matrices. Generalized to apply to more Hermitian matrices, the nature of the pseudospectrum changes radically, often having interesting geometry.

Laurent W. Marcoux (University of Waterloo). *Hilbert space operators with compatible off-diagonal corners*

Given a complex, separable Hilbert space $\mathcal{H}$, we characterize those operators for which $\|PT(I-P)\| = \|(I-P)TP\|$ for all orthogonal projections P on $\mathcal{H}$. When $\mathcal{H}$ is finite-dimensional, we also obtain a complete characterization of those operators for which $\operatorname{rank}(I-P)TP = \operatorname{rank} PT(I-P)$ for all orthogonal projections P. When $\mathcal{H}$ is infinite-dimensional, we show that any operator with the latter property is normal, and its spectrum is contained in either a line or a circle in the complex plane. This is joint work with L. Livshits, G. MacDonald, and H. Radjavi.

Robert Martin (University of Cape Town). *The free Smirnov Class*

We prove that any closed, densely-defined operator is affiliated to the right free shift of the full Fock space over $\mathbb{C}^d$ if and only if it acts as right multiplication by a free holomorphic function in the right free Smirnov class. Here the Fock space is identified with the free Hardy space of bounded free holomorphic functions on the open non-commutative multi-variable unit ball, and the right free Smirnov class is the algebra of ratios of right free multipliers with outer denominator.

Several further characterizations and applications including Lebesgue decomposition of free Aleksandrov-Clark functionals will be discussed. This is joint work with Michael Jury.

Satish Pandey (University of Waterloo). *Entanglement Breaking Rank*

A quantum channel is entanglement breaking if and only if it admits a Choi-Kraus representation consisting of rank-one Choi-Kraus operators. We define the entanglement breaking rank of an entanglement breaking channel to be the least number of such rank-one operators required in its Choi-Kraus representation. We show that the problem of computing the entanglement breaking of the channel:

$$X \mapsto \frac{1}{d+1}(X + \mathrm{Tr}(X)I_d),$$

is equivalent to the existence problem of SIC POVM in dimension d.

Sarah Plosker (Brandon University). *Operator-valued Lyapunov theorems*

We generalize Lyapunov's convexity theorem for classical (scalar-valued) measures to quantum (operator-valued) measures. In particular, we show that the range of a nonatomic quantum probability measure is a closed convex set of quantum effects (positive operators whose eigenvalues are less than or equal to one). This is joint work with Christopher Ramsey.

Christopher Ramsey (University Manitoba–Brandon University). *Residually finite-dimensional operator algebras*

It is well known that finite-dimensional C*-algebras are given by direct sums of matrix algebras. Such a nice characterization is not possible for finite-dimensional (non-selfadjoint) operator algebras. Instead it will be shown that such algebras are residually finite-dimensional, that is, they have a a family of completely contractive representations onto finite-dimensional Hilbert space whose direct sum is a complete isometry. I will talk about these concepts and discuss examples. This is joint work with Raphael Clouatre.

Ana Savu (University of Alberta). *Solid-on-Solid models*

A crystal is a solid in which the atoms form a periodic arrangement. For many practical applications, understanding structural atomic arrangement and processes governing formation of crystals are essential to obtain useful properties. A special class of models so called Solid-on-Solid models are used to study the equilibrium statistical mechanics of surfaces. Several discrete Solid-on-Solid models and partial differential equations for surface diffusion are discussed.

Khodr Shamseddine (University of Manitoba). *Elements of an operator theory on the space c_0 over a non-Archimedean valued field (Part II)*

Let c_0 be the space of null sequences in a non-Archimedean valued field of rank 1. In this talk, we will study the properties of positive operators on c_0 which are similar to those of positive operators in classical functional analysis; however the proofs of many of the results are non-classical. Then we will use our study of positive operators to introduce a partial order on the algebra of self-adjoint operators on c_0 that satisfy the spectral theorem and study the properties of that partial order.

Dominik Schillo (Universität des Saarlandes). *K-contractions*

In this talk, I present a unified framework for the model theory of special classes of commuting operators associated with reproducing kernel. For example, the class of m-hypercontractions studied by Müller and Vasilescu corresponds to the Bergman kernel, or the class of commuting operators studied by Clouatre and

Hartz which corresponds to complete Nevanlinna-Pick kernels. As an application, we give a Beurling-type theorem in this general framework.

Edward Timko (University of Manitoba). *C_0-type Results for Commuting Row Contractions*

We recall that C_0 operators possess an analog of both the minimal polynomial and the Jordan form from elementary linear algebra. We then demonstrate similar results for a special classes of rows contractions. Specifically, we consider commuting row contractions $T = (T_1, \ldots, T_d)$ with annihilating ideal $\mathrm{Ann}(T)$ equal to the annihilating ideal of an interpolating sequence for the multiplier algebra of the Drury-Arveson space $\mathcal{M}_d$. For such T, we obtain similarity to a d-tuple of diagonal operators. We also discuss an extension to a larger class of ideals in $\mathcal{M}_d$. This is joint work with Raphaël Clouâtre.

Pei-Lun Tseng (Queen's University). *Linearization trick in infinitesimal freeness*

Assume that we know the infinitesimal distribution of selfadjoint elements X and Y. Give an selfadjoint polynomial P with variables X and Y. The natural question is whether we can write down the precise formula for the infinitesimal distribution of $P(X,Y)$? In 2009 Belinschi and Shlyakhtenko gave a precise formula to solve for the infinitesimal distribution of P for $P(X,Y) = X+Y$. In the talk, we will introduce the concept of infinitesimal freeness and linearization trick in free probability, and discuss how to find the formula for an arbitrary polynomial by using the linearization trick.

Matthew Wiersma (University of Alberta). *Tracial States and Group Structure*

A tracial state on a C*-algebra A is a state $\tau \in A^*$ so that $\tau(ab) = \tau(ba)$ for all $a, b \in A$. The theory of tracial states is extremely important within the theory of C*-algebras. We will discuss the relationship between tracial states on the full group C*-algebra $\mathrm{C}^*(G)$ of a locally compact group G and the structure of the underlying group G. This talk is based on joint work with Brian Forrest and Nico Spronk.