GPOTS 2024 Abstracts

University of Nebraksa–Lincoln

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Plenary Talks

Amenability and approximation properties for C*-algebraic dynamical systems

Alcides Buss – *Universidade Federal de Santa Catarina*

Abstract: In this lecture we introduce an "approximation property" that applies to generalized forms of C*-dynamical systems. In the most general form, this means that we have a groupoid or an inverse semigroup acting on a C*-algebra, either by automorphisms or equivalence bimodules, which is the same as having a so-called Fell bundle over the groupoid or inverse semigroup.

These objects contain the classical actions of groups on C*-algebras and their associated crossed products, and in that case, the approximation property is equivalent to amenability of the underlying action in the sense of Anantharaman-Delaroche from 1987. More generally, for Fell bundles over groups, it captures the approximation property introduced by Exel in 1997.

In general, the approximation property should be viewed as a form of nuclearity of the cross-sectional C*-algebra of the Fell bundle. Indeed, one of our main results is that the approximation property implies nuclearity of the cross-sectional C*-algebra assuming that the unit fiber (i.e. the acting C*-algebra) is nuclear. For groups, the converse also holds, and it is an open problem whether it holds in general, for groupoids or inverse semigroups.

This talk is based on several joint works with Diego Martinez, Fernando Abadie, Damian Ferraro, Camila Sehnem, Siegfried Echterhoff, and Rufus Willett.

(Generalized) Inductive Systems of C*-algebras

Kristin Courtney – *University of Southern Denmark*

Abstract: Inductive limits are a central construction in operator algebras because they allow one to construct complicated objects with tractable properties using well-understood

building blocks, such as finite-dimensional C*-algebras. In the classical setting, the only nuclear C*-algebras that arise as inductive limits of finite-dimensional C*-algebras are the AF algebras. In order to construct a broader class of nuclear C*-algebras in this way, Blackadar and Kirchberg introduced a more generalized notion of inductive systems of C*-algebras with connecting maps that asymptotically look like *-homomorphisms. With these, they could build any quasidiagonal nuclear C*-algebra as a limit of finite-dimensional C*-algebras. By introducing more flexibility into their systems, we can now give such an inductive limit construction for any separable nuclear C*-algebra. In this talk, I will discuss Blackadar and Kirchberg's generalized inductive systems and the recently introduced soft inductive systems (van Luijk–Stottmeister–Werner), CPC*-systems (C.–Winter), and C*-encoding systems (C.). The structure encoded by these systems is quite natural, and these systems directly correspond to completely positive approximations of nuclear C*-algebras and operator systems. This is based in part on joint work with Niklas Galke, Lauritz van Luijk, Alexander Stottmeister, and Wilhelm Winter.

Structural Properties of von Neumann Algebras from Groups and Graph Products

Rolando de Santiago – *California State University, Long Beach*

Abstract: Fundamental properties of von Neumann algebras, such as amenability, factoriality, primeness, and fullness have been critical in the classification of von Neumann algebras. We examine structural properties of von Neumann algebras arising from groups as well as graph products. In the setting of graph product von Neumann algebras, we give characterizations of when the algebras can be amenable, a factor, prime, or full. Moreover, we will show how to deduce relative amenability in graph product von Neumann algebras as well as graph products of groups. This is based on work done jointly with an Ian Charlesworth, Ben Hayes, David Jekel, Srivatsav Kunnawalkam Elayavalli, and Brent Nelson

Expansive systems and their C*-algebras

Robin Deeley – *University of Colorado Boulder*

Abstract: An expansive dynamical system is a pair (X, f) where X is a compact metric space and f is a homeomorphism that is sensitive to initial conditions. An important subclass of expansive dynamical systems are Smale spaces. Building on work of Ruelle and Putnam, Thomsen has constructed C*-algebras associated with such a system. I will discuss the structure of these C*-algebras and compare the results for general expansive systems, Smale spaces, and another important class called synchronizing systems. Knowl-

edge of the definitions of expansive, Smale space, and synchronizing are not required as they will be introduced in the talk.

This talk is based on joint work with Andrew Stocker. This work was partially supported by NSF DMS grants 2000057 and 2247424.

The dynamical Kirchberg-Phillips theorem

Jamie Gabe – *University of Southern Denmark*

Abstract: The purely infinite simple nuclear C*-algebras are a prominent class of operator algebras with the most famous examples being the Cuntz algebras $\mathcal{O}_n$. These C*-algebras were classified by Kirchberg and Phillips in the mid 90's. I will talk about the problem of classifying C*-dynamical systems for which the underlying C*-algebra is purely infinite simple nuclear, and give at least one basic example of what can be deduced from our work. This is joint work with Gabor Szabo.

Higher-rank graphs: challenges and applications

Elizabeth Gillaspy – *University of Montana*

Abstract: Higher-rank graphs, or k-graphs, are a k-dimensional generalization of directed graphs (1-graphs). They were introduced by Kumjian and Pask in 2000 to provide combinatorial and concrete models for C*-algebras, generalizing the graph C*-algebra construction. Despite their combinatorial character, k-graphs have received little attention outside the C*-algebra community, though this may be changing.

In this talk, I will introduce higher-rank graphs and their C*-algebras, and highlight topics within C*-algebra theory (ranging from nuclear dimension to real C*-algebras) where k-graphs have given rise to key insights. I will also discuss some intriguing connections between k-graphs and other areas of mathematics such as dynamical systems and geometric group theory.

This talk will be largely expository; my goal is that regardless of your prior familiarity with higher-rank graphs, by the end of the talk you will have a renewed appreciation for k-graphs and their C*-algebras.

Trace spaces of full free product C*-algebras

Adrian Ioana – *UCSD*

Abstract: The space of traces $T(A)$ of a unital, separable C*-algebra A is a metrizable Choquet simplex. I will present a new result showing that if $A = A_1 * A_2$ is a full free

product of unital, separable C*-algebras, then T(A) is typically a Poulsen simplex, i.e., the extreme traces are dense in T(A). This result implies that T(A) is a Poulsen simplex whenever A_1 and A_2 have no 1-dimensional representations, e.g., when A_1 and A_2 are finite dimensional and have no 1-dimensional direct summands. Additionally, it allows to characterize when the space of traces of the full C*-algebra $C^*(G)$ of a free product of countable groups $G = G_1 * G_2$ is Poulsen. The method of proof relies on a new perturbation theorem for pairs of tracial von Neumann algebras (M_1, M_2) which gives necessary conditions ensuring that M_1 and a small unitary perturbation of M_2 generate a II$_1$ factor. This is based on joint work in preparation with Pieter Spaas and Itamar Vigdorovich.

Random Commuting Matrices

John McCarthy – *Washington University*

Abstract: The study of the eigenvalue distribution of random matrices is a well-established field, dating back to the 1920's. It became popular with the work of Wigner and Dyson in the 1950's and 60's, and today is a major field in both probability and theoretical physics. Typically a random matrix is generated by choosing the entries identically and independently distributed.

What can one say about random d-tuples of commuting matrices? What does it even mean, since one can no longer choose entries independently?

We will describe one approach to defining a random d-tuple of commuting matrices. We shall show that in the Hermitian case, the description of their eigenvalue distribution parallels to some extent the single matrix theory, though there is a qualitative change when $d \geq 5$. In the non-self adjoint case the eigenvalue distribution is quite unlike the single matrix case.

Almost periodic states

Brent Nelson – *Michigan State University*

Abstract: Almost periodicity for a faithful normal state on a von Neumann algebra is a notion introduced by Connes that implies its modular automorphism group admits a natural compactification. In other words, the modular theory of such a state is comparatively tame, to the point that one has the impression that such states are almost tracial. This proximity to the tracial case can be made explicit through various properties, and is further evidenced by extensions of tracial results to the almost periodic case. In this talk, I will highlight a few of these extensions after providing an introduction to almost periodic states and the relevant modular theory. No background in Tomita–Takesaki theory will be assumed, but I hope to leave you with an desire to think beyond the tracial case.

Biexactness and proper proximality

Jesse Peterson – *Vanderbilt University*

Abstract: We will give an overview of the recent developments of the notions of biexactness and proper proximality in the setting of von Neumann algebras. We'll explain what these notions are and how they are used in von Neumann algebras. We'll highlight examples, applications, and open problems. The aim will be to make this accessible to a wide audience familiar with operator algebras.

A NASA Perspective on Quantum Computing, with Ties to Operator Algebras

Eleanor Rieffel – *NASA Ames Research Center*

Abstract: The talk will survey work done by the NASA Quantum Artificial Intelligence Laboratory (QuAIL), particularly algorithms and protocols in which operator algebras may play a role. The talk will focus on recent work advancing quantum error correction and error mitigation, and will touch on other topics related to quantum algorithms and fundamental quantum physics.

Operator system approaches to some open problems in quantum information theory

Travis Russell – *Texas Christian University*

Abstract: Although the two fields have always been fundamentally connected, interest in quantum information theory among operator algebraists surged over the past decade as surprising connections were found between Tsirelson's problems on quantum correlations and Connes' embedding problem. As a result, many fruitful collaborations formed, eventually culminating in the recent solution to Connes' embedding problem. The aim of this talk is to draw attention to other problems in quantum information theory which remain open and may be of interest to the operator algebras community. Time permitting, I'll also discuss some approaches towards these problems using primarily operator system techniques. This talk is intended to be accessible to non-experts including graduate students.

Some examples of C^*-algebras constructed from left cancellative small categories

Jack Spielberg – *Arizona State University*

Abstract: LCSCs (left cancellative small categories) provide generalizations of directed graphs and higher rank graphs as well as of submonoids of groups. The construction of C^*-algebras from graphs and higher rank graphs, as developed by Kumjian, Pask, Raeburn, Renault, Sims, Yeend (and countless others), and from monoids, as pioneered by Nica and Li, all can be viewed as special cases of C^*-algebras constructed from LCSCs. Moreover, the axioms for an LCSC are nearly nonexistent, in dramatic contrast to the case of higher rank graphs, for example. I will briefly review the construction of C^*-algebras from LCSCs, and then will present three examples illustrating the flexibility of this setting.

Classifiable C*-algebras from topological dynamics

Karen Strung – *Institute of Mathematics of the Czech Academy of Sciences*

Abstract: One of the most dramatic recent advances in operator algebras is the classification of separable, unital, simple, nuclear C*-algebras which are Jiang–Su stable and satisfy the UCT. With this abstract classification theorem in hand, we are left with questions about which ”naturally occurring” C*-algebras are covered by the theorem. By “naturally occurring” I mean operator algebraic models of various mathematical structures. These have long played an important role, as they allow one to use a well-stocked toolkit consisting of both algebraic and analytic equipment to study such various mathematical objects. An example of this is the relationship between topological dynamical systems and C*-algebras. In this talk I will discuss examples of classifiable C*-algebras given by various constructions arising from topological dynamical systems.

Contributed Talks

Quantum Gromov-Hausdorff propinquity convergence of Christensen-Ivan quantum metrics on AF algebras

Konrad Aguilar – *Pomona College*

Abstract: We provide convergence in the quantum Gromov-Hausdorff propinquity of Latrémolière of some sequences of infinite-dimensional Leibniz compact quantum metric spaces of Rieffel given by AF algebras and Christensen-Ivan spectral spaces. The main examples are convergence of Effros-Shen algebras and UHF algebras. (This is joint work with Clay Adams, Esteban Ayala, Evelyne Knight, and Chloe Marple. This work is partially supported by NSF grant DMS-2316892.

Relative Solidity Results for $\mathbf{II}_1$ factors associated with relative hyperbolic groups and their applications to computation of

Dulanji Amaraweera – *University of Iowa*

Abstract: I will discuss some remarks on relative solidity for von Neumann algebras associated with large classes of relative hyperbolic groups. I will also explain the group-theoretic and deformation/rigidity techniques we used to derive these results. These structural outcomes offer new insights into some well-known primeness questions for von Neumann algebras. Finally, I will demonstrate some computations of invariants as an application to our solidity results.

Twisted groupoid C*-algebras and finite nuclear dimension

Astrid an Huef – *Victoria University of Wellington*

Abstract: Let E be a twist over a principal étale groupoid G. I will talk about the main ideas of joint work with Kristin Courtney, Anna Duwenig, Magdalena Georgescu and Maria Grazia Viola, where we proved that the nuclear dimension of the reduced twisted groupoid C^*-algebra is bounded by a number depending on the dynamic asymptotic dimension of G and the topological covering dimension of its unit space. This generalises an analogous theorem by Guentner, Willet and Yu for the C^*-algebra of G. Our proof uses a reduction to the unital case where G has compact unit space, via a construction of "groupoid unitisations" $\widetilde{G}$ and $\widetilde{E}$ of G and E such that $\widetilde{E}$ is a twist over $\widetilde{G}$.

Rigidity for W^*-McDuff groups

Juan Felipe Ariza Mejía – *University of Iowa*

Abstract: The problem of understanding how much of the group G is remembered by the group von Neumann algebra $L(G)$ has been a major research theme in the field of operator algebras. On one extreme of the rigidity question are W^*-superrigid groups, those which are completely recoverable from the von Neumann algebra $L(G)$. On the other extreme, there is the class of icc amenable groups each of which generates the hyperfinite II_1 factor. In between these two extremes of superrigidity, and complete lack thereof, there are many classes of non-amenable groups that display various rigidity phenomena. In our work, we introduce the first examples of groups whose lack of superrigidity can be completely characterized. Specifically, we introduce the notion of, and construct, groups that are McDuff W^*-superrigid, that is groups G such that if $L(G) = L(H)$ (for an arbitrary group H), then $H = G \times A$ for some icc amenable group A. We do this by introducing new geometric group theory methods to construct wreath-like product groups with a 2-cocycle with uniformly bounded support, and using the interplay between two types of deformations on their group von Neumann algebra to prove that such groups have infinite product rigidity. This is ongoing work with Ionuţ Chifan, Denis Osin and Bin Sun.

Extensions of the Mandelbrot set and filled Julia sets to C*-algebras

David Benson – *University of New Hampshire*

Abstract: In this talk, we define an extension of the Mandelbrot set and filled Julia sets for C*-algebras. We explore similarities and differences between the traditional Mandelbrot set and filled Julia sets and their generalizations. We give sufficient and necessary conditions on the C*-algebra for the associated Mandelbrot set to be compact. We explore properties of Mandelbrot sets in terms of constructions with C*-algebras. Visualizations of the obtained sets are shown.

A Normalized Cauchy Transform for Higher Dimensions

Chad Berner – *Iowa State University*

Abstract: The Normalized Cauchy Transform is a map from square integrable functions on a measure space to analytic functions on the disk that encodes information about the measure. Additionally, if the measure is singular, this map is a unitary onto the corresponding model space. Using an operator version of the Kaczmarz algorithm and the Rokhlin Theorem, we were able to develop a Normalized Cauchy Transform for measures we call "slice-singular" in higher dimensions. We discuss the image of this transform, which is a

subset of the Hardy space of the bi-disk, and we explore its relation with model spaces using de Branges theory. Furthermore, we will discuss properties of this transform such as behavior at the boundary and backward shift invariance. Finally, we establish a Beurling type result for images of these transforms. (joint work with John Herr, Palle Jorgensen, and Eric Weber)

Near- Riesz bases

Deborpita Biswas – *Clemson University*

Abstract: James R. Holub, in one of his papers in 1994, introduced the influential concept of near-Riesz bases as frames which become Riesz bases after removal of finitely many terms. We recently extended his definition of near- Riesz basis to sequences which are not frames. In this talk I will present a characterization of our extended near-Riesz bases in terms of the Fredholmness of their associated synthesis operator. I will also present some perturbation results for our near-Riesz bases.

Spectral triples on a non-standard presentation of Effros-Shen AF algebras

Samantha Brooker – *Arizona State University*

Abstract: The Effros-Shen algebra corresponding to an irrational number θ can be described by an inductive sequence of direct sums of matrix algebras, where the continued fraction expansion of θ encodes the dimensions of the summands, and how the matrix algebras at the nth level fit into the summands at the $(n+1)$th level. In recent work, Mitscher and Spielberg present an Effros-Shen algebra as the C^*-algebra of a category of paths – a generalization of a directed graph – determined by the continued fraction expansion of θ. With this approach, the algebra is realized as the inductive limit of a sequence of infinite-dimensional, rather than finite-dimensional, subalgebras. We define a spectral triple in terms of the category of paths presentation of an Effros-Shen algebra, drawing on a construction by Christensen and Ivan. This is joint work with Konrad Aguilar and Jack Spielberg.

The exotic Cuntz algebra is a rank-3 graph algebra

Sarah Browne – *University of Kansas*

Abstract: The exotic Cuntz algebra $\mathcal{E}_n$ is a simple purely infinite real C*-algebra whose complexification is the Cuntz algebra $\mathcal{O}_n$. In 2011, this algebra was identified abstractly by

Boersema–Ruiz–Stacey using K-theory arguments and until recently not much was known about $\mathcal{E}_n$. We prove that the exotic Cuntz algebra is stably isomorphic to a real C*-algebra of a rank-3 graph with involution. This is based on joint work with J. Boersema and E. Gillaspy.

New hyperfinite subfactors with infinite depth

Julio Caceres – *Vanderbilt University*

Abstract: We will discuss the construction of new examples of irreducible, hyperfinite subfactors with trivial standard invariant and "interesting" Jones indices. More specifically, we will use two graph planar algebra embedding theorems and the classification of small index subfactors to show that certain commuting square subfactors cannot have finite depth. This is joint work with Dietmar Bisch.

Even hypergeometric polynomials and finite free probability

Jacob Campbell – *University of Virginia*

Abstract: In 2015, Marcus, Spielman, and Srivastava realized that expected characteristic polynomials of sums and products of randomly rotated matrices behave like finite versions of Voiculescu's free convolution operations. In 2022, I obtained a similar result for commutators of such random matrices; one feature of this result is the special role of even polynomials, in parallel with the situation in free probability.

It turns out that a certain family of special polynomials, called hypergeometric polynomials, arises naturally in relation to convolution of even polynomials and finite free commutators. I will explain how these polynomials can be used to approach questions of real-rootedness and asymptotics for finite free commutators, and how they provide a systematic framework for the main examples. Based on arXiv:2209.00523 and ongoing joint work with Rafael Morales and Daniel Perales.

Measurement of non-compactness of Sobolev embedding into variable Lorentz space

Chian Yeong Chuah – *Ohio State University*

Abstract: The investigation of Sobolev embedding into Lebesgue spaces and Lorentz spaces is pivotal in the realms of PDE and approximation theory. In classical contexts, the Rellich–Kondrachov theorem delineates conditions under which Sobolev embedding achieves compactness. However, when the embedding lacks compactness, diverse metrics

exist to gauge the degree of non-compactness. This presentation explores the compactness of Sobolev embedding into variable Lorentz spaces, focusing on the concentration of non-compactness around a singular point. Additionally, the quality of non-compactness within this framework is also discussed.

Peripheral Poisson boundary and jointly bi-harmonic functions

Sayan Das – *Embry-Riddle Aeronautical University, Prescott*

Abstract: The study of asymptotic properties of a random walk on a countable, discrete group G (with respect to a symmetric, generating probability measure) relies on understanding a natural boundary of the random walk, called the Poisson boundary. The study of Poisson boundaries is intimately related with the study of bounded harmonic functions on groups. The startling "double ergodicity theorem" of Kaimanovich states that (separately) bi- harmonic functions on groups is constant- a feature that has led to the discovery of many rigidity properties of group representations and group actions. This led Kaimanovich to ask about the characterization of (jointly) bi-harmonic functions. In this talk I will completely characterize bi-harmonic functions on groups, thereby answering Kaimanovich's question, that he posed in 1992. I will also introduce the notion of "Peripheral Poisson boundaries", which was first considered in a recent paper of Bhat, Talwar and Kar (2022). I will completely characterize the peripheral Poisson boundaries of groups, thereby answering a recent question of Bhat, Talwar and Kar.

Cohomology of étale groupoids (joint with M. Ionescu)

Valentin Deaconu – *University of Nevada, Reno*

Abstract: We introduce a cochain complex for étale groupoids $\mathcal{G}$ by dualizing the chain complex defining their homology with coefficients in $\mathbb{Z}$. We prove that the homology of this cochain complex coincides with the previously introduced sheaf cohomology and continuous cocycle cohomology of $\mathcal{G}$. This groupoid cohomology is invariant under Morita equivalence. We compute the cohomology for AF-groupoids and for certain action groupoids.

Primeness for the von Neumann Algebra of the Higman-Thompson Group V_d

Patrick DeBonis – *Purdue University*

Abstract: Popa's deformation/rigidity theory has provided a robust framework for showing results like primeness for von Neumann algebras arising from groups. We adapt this

method for certain groups admitting unbounded cocycles into quasi-regular representations to prove results about primeness, proper proximality and primeness for actions for the Higman-Thompson groups V_d. This is joint work with Rolando de Santiago and Krishnendu Khan.

Multiplier Algebras of L^p-operator Algebras.

Alonso Delfín Ares de Parga – *University of Colorado-Boulder*

Abstract: I will begin the talk with a brief introduction of algebras of operators acting on L^p spaces. I will discuss some of their main differences with C*-algebras such as (1) failure of nondegenerate representations, (2) nonexistence of contractive approximate units, and (3) non uniqueness of L^p-operator norms. I will then focus on a particular problem in which, given an L^p-operator algebra A, we study when $M(A)$ (the multiplier algebra of A) can be isometrically represented on an L^p space. This is part of a joint work with Andrey Blinov and Ellen Weld.

Quantum harmonic analysis on spaces of analytic functions

Vishwa Dewage – *Clemson University*

Abstract: It was shown recently by Fulsche that techniques from Werner's quantum harmonic analysis (QHA) have some fascinating applications in the theory of Toeplitz operators on the Fock space. However, applying QHA techniques to the Bergman space over the unit ball turned out to be significantly more difficult due to the non-commutativity of the group acting on the unit ball. We modify Suarez's higher-order Berezin transform via QHA notions and discuss Toeplitz algebras using QHA techniques.

Shift Operators Defined On Power Series Spaces

Nazlı Doğan – *University of Toledo*

Abstract: Frechet spaces represent a primary class among locally convex spaces, housing a majority of the significant examples of non-normable locally convex spaces. Dynin Mitiagin Theorem states that nuclear Frechet spaces with a Schauder basis have a Köthe space representation. Power series spaces form an important family of Kothe spaces and they contain the spaces of holomorphic functions. In this presentation, following the introduction of these spaces, we will present some properties of shift operators defined on power series spaces.

W*-superrigidity for cocycle twisted group von Neumann algebras

Milan Donvil – *KU Leuven*

Abstract: To any countable group G one can canonically assign a von Neumann algebra $L(G)$. Typically, in the transition from G to $L(G)$ most information about G is lost. However, for specific classes of groups, $L(G)$ completely remembers the group G in the following sense: if $L(G)$ is isomorphic to $L(H)$ for another countable group H, then G is isomorphic to H. In this case, we say that G is a W*-superrigid group. In a recent joint work with Stefaan Vaes, we generalize W*-superrigidity for groups in two directions. Firstly, we provide a class of groups G for which W*-superrigidity holds in the presence of a 2-cocycle: if H is any countable group and ω and η are any 2-cocycles on G and H respectively, we have that the twisted group von Neumann algebras $L_\omega(G)$ and $L_\eta(H)$ are isomorphic if and only if the pairs (G, ω) and (H, η) are isomorphic. Secondly, for this same class of groups, the superrigidity also holds up to virtual isomorphism.

Nuclear Dimension of Graph C^*-Algebras

Gregory Faurot – *University of Nebraska-Lincoln*

Abstract: Nuclear dimension has been an important tool used in the classification of simple C^*-algebras. When A is an extension of a C^*-algebra B by an ideal I, the nuclear dimensions of B and I provide an upper bound on the nuclear dimension of A. However, this upper bound is usually very far from being tight. A series of results over the last several years have improved the upper bound in many important cases. Graph C^*-algebras provide an excellent source of examples of extensions, especially in the presence of Condition (K). In this talk, after providing some background on nuclear dimension and graph algebras, I will discuss some results on the nuclear dimension of graph C^*-algebras. This work is joint with Christopher Schafhauser.

Rigidity results for group von Neumann algebras with diffuse center

Adriana Fernández Quero – *University of Iowa*

Abstract: We introduce the first examples of groups G with infinite center which in a natural sense are completely recognizable from their von Neumann algebras, $\mathcal{L}(G)$. Specifically, assume that $G = A \times W$, where A is an infinite abelian group and W is an ICC wreath-like product group with property (T), trivial abelianization and torsion free outer automorphism group. Then whenever H is an *arbitrary* group such that $\mathcal{L}(G)$ is $*$-isomorphic to $\mathcal{L}(H)$, via an *arbitrary* $*$-isomorphism preserving the canonical traces, it must be the case that $H = B \times H_0$ where B is infinite abelian and H_0 is isomorphic to W. Moreover, we

completely describe the $*$-isomorphism between $\mathcal{L}(G)$ and $\mathcal{L}(H)$. This yields new applications to the classification of group C*-algebras, including examples of non-amenable groups which are recoverable from their reduced C*-algebras but not from their von Neumann algebras. This is joint work with Ionuţ Chifan and Hui Tan.

On the continuity of intertwining operators over generalized convolution algebras

Felipe Flores – *University of Virginia*

Abstract: Let G be a locally compact group, $\mathscr{C} \overset{q}{\to} \mathsf{G}$ a Fell bundle and $\mathfrak{B} = L^1(\mathsf{G}\,|\,\mathscr{C})$ the algebra of integrable cross-sections associated to the bundle. We give conditions that guarantee the automatic continuity of an intertwining operator $\theta : \mathcal{X}_1 \to \mathcal{X}_2$, where $\mathcal{X}_1$ is a Banach $\mathfrak{B}$-bimodule and $\mathcal{X}_2$ is a weak Banach $\mathfrak{B}$-bimodule, in terms of the continuity ideal of θ. We provide examples of algebras where this conditions are met, both in the case of derivations and algebra morphisms. In particular, we show that, if G is infinite, finitely-generated, has polynomial growth and α is a free (partial) action of G on the compact space X, then every homomorphism of $\ell^1_\alpha(\mathsf{G}, C(X))$ into a Banach algebra is automatically continuous.

Sofic actions on sets and applications to generalized wreath products

David Gao – *University of California, San Diego*

Abstract: Inspired by the work of Hayes and Sale showing wreath products of two sofic groups are sofic, we define a notion of soficity for actions of countable discrete groups on countable discrete sets. We shall prove that, if the action α of G on X is sofic, G is sofic, and H is sofic, then the generalized wreath product $H \wr_\alpha G$ is sofic. We shall demonstrate several examples of sofic actions, including actions of sofic groups with locally finite stabilizers, all actions of amenable groups, and all actions of LERF groups. This talk is based on joint work with Srivatsav Kunnawalkam Elayavalli and Gregory Patchell.

Schreier's Formula for some Free Probability Invariants

Aldo Garcia Guinto – *Michigan State University*

Abstract: Let $G \overset{\alpha}{\curvearrowright} (M, \tau)$ be a trace-preserving action of a finite group G on a tracial von Neumann algebra. Suppose that $A \subset M$ is a finitely generated unital $*$-subalgebra which is globally invariant under α. We give a formula relating the von Neumann dimension of the

space of derivations on A valued on its coarse bimodule to the von Neumann dimension of the space of derivations on $A \rtimes_{\alpha}^{\text{alg}} G$ valued on its coarse bimodule, which is reminiscent of Schreier's formula for finite index subgroups of free groups. This formula induces a formula for $\dim \mathrm{Der}_c(A, \tau)$ (defined by Shlyakhtenko) and under the assumption that G is abelian we obtain the formula for Δ (defined by Connes and Shlyakhtenko). These quantities and the free entropy dimension quantities agree on a large class of examples, and so by combining these results with known inequalities, one can expand the family of examples for which the quantities agree.

Topological Quiver C*-Algebras & Principle Actions

Matthew Gillespie – *Arizona State University*

Abstract: Topological quivers are a somewhat natural generalization of topological graphs, where we insist that edge space is additionally endowed with a family of Radon measures, indexed by the vertex space, satisfying some regularity conditions. We aim to present a 'down to earth' discussion for the needed background material to understand what a topological quiver C*-algebra is, as well as discuss some results we hope to generalize from Deaconu, Kumjian and Quigg in the topological graph setting. One of these main results being that a locally compact group acting freely and properly on a topological quiver induces a Morita equivalence between the reduced crossed product of the quiver C*-algebra and the C*-algebra of the corresponding 'quotient quiver'. This is a joint work with Lucas Hall and Mariusz Tobolski.

When Does 2-Cohomology Obstruct Frobenius Stability?

Forrest Glebe – *Purdue University*

Abstract: A group is said to be Frobenius stable if every map from the group to unitary matrices that is "almost multiplicative" in the point-unnormalized 2-norm topology, is "close" to a genuine unitary representation in the same topology. A result of Dadarlat shows that even rational cohomology obstructs the analogous notion in operator norm. A result of mine uses 2-cohomology to show that most finitely generated nilpotent groups are not Frobenius stable. However, a class of examples due to Bader, Lubotzky, Sauer, and Weinberger demonstrate that in general, non-torsion 2-cohomology does not obstruct Frobenius stability. In this talk, I will sketch a proof of my recent result that if a finitely generated group has a non-torsion integer 2-cohomology class that can be written as a cup product of two 1-cohomology classes that group is not Frobenius stable.

Wavelet MRAs, Groupoid C^*-algebras, and Blaschke Composition Operators - Oh My! (Part 2)

Marius Ionescu – *U. S. Naval Academy*

Abstract: This is the second part of a pair of talks on joint work with Paul Muhly. In it we reveal the *secret sauce* that allows us to induce certain C^*-representations of $C^*(G(X_\infty, \sigma_\infty))$ on Hilbert space that yield bona fide (generalized) multiresolutions. When we specialize to the case when $X = \mathbf{T}$ and σ is the map $z \mapsto z^2$, our analysis obtains all the MRAs studied by Mallat.

The "secret sauce" is the concept of a *section* for the natural projection p from X_∞ to X. This is simply a Borel function $s : X \to X_\infty$ such that $p(s(x)) = x$ for all $x \in X$. We say that s is *positively supported* with respect to $\{\nu^D_{x,\infty}\}_{x\in X}$ in case $\nu^D_{x,\infty}(\{s(x)\}) > 0$ for all $x \in X$. It turns out that the regular representation of $C^*(G(X_\infty, \sigma_\infty))$ determined by $\{\nu^D_{x,\infty}\}_{x\in X}$ gives a bona fide (generalized) MRA precisely when there is a section that is positively supported with respect to $\{\nu^D_{x,\infty}\}_{x\in X}$.

We show that this condition is effective when analyzing wavelets in $L^2(\mathbf{R})$ and that it may be used to build wavelets based on composition operators determined by certain finite Blaschke products.

Von Neumann equivalence and group approximation properties

Ishan Ishan – *University of Nebraska-Lincoln*

Abstract: The notion of von Neumann equivalence, which generalizes both measure equivalence and W^*-equivalence, was introduced by Jesse Peterson, Lauren Ruth, and myself. In this talk, I will discuss a few group approximation properties that are stable under von Neumann equivalence, particularly focusing on the stability of weak amenability, weak Haagerup property, and the approximation property (of Haagerup and Kraus) under von Neumann equivalence.

Distinguishing between quantum Cuntz-Krieger and local quantum Cuntz-Krieger algebras

Lara Ismert – *ERAU*

Abstract: Quantum graphs are noncommutative generalizations of finite graphs that have been of significant interest in recent years. In this talk, we will discuss two C*-algebras associated to a quantum graph, the quantum Cuntz-Krieger (QCK) algebra and the local QCK algebra of a quantum graph, and give the first example of a quantum graph with

distinct QCK and local QCK algebras. This is based on joint work with Mitch Hamidi and Brent Nelson.

A look at the topologies of Kasparov's groups

Arturo Jaime – *University of Hawai'i at Mānoa*

Abstract: One interesting property of Kasparov's KK groups is that they admit the structure of a (possibly non-Hausdorff) topological group. The KL-group, $KL(A, B)$, the quotient of $KK(A, B)$ by the closure of $\{0\}$, has played an important role in the classification of C^*-algebras. Recently Willett and Yu have used a controlled picture of KK-theory to describe KL as an inverse limit of controlled KK-groups. Taking advantage of this inverse limit structure on KL one can make more explicit topological structures. We show that this allows to classify the possible topologies arising from such an inverse system up to homeomorphism. This is a report on work in progress.

The definable closure in tracial von Neumann algebras

David Jekel – *Fields Institute, York University*

Abstract: The definable closure of a set in some structure is a concept from the model theory of metric structures. A lot of recent work has connected model theory with tracial von Neumann algebras, including my own work on model theory and free entropy and free optimal transport. The definable closure of $A \subseteq M$ is something like a Galois closure with respect to the action of automorphisms of M, assuming that M is a suitably large model of its theory. I will show that elements of the definable closure of A can be expressed as definable functions applied to the elements of A, using ideas from convex analysis and PDE. I will also give several examples illustrating the behavior of definable closure.

Topological Quiver C*-Algebras & Group Actions

Benjamin Jones – *Arizona State University*

Abstract: Topological quivers are a somewhat natural generalization of topological graphs, where we insist that edge space is additionally endowed with a family of Radon measures, indexed by the vertex space, satisfying some regularity conditions. In this series of talks, we aim to present the needed background material to understand what a topological quiver C*-algebra is, as well as discuss some results we hope to generalize from Deaconu, Kumjian and Quigg in the topological graph setting. One of these main results is that a locally compact group acting freely and properly on a topological quiver induces a Morita equivalence

between the reduced crossed product of the quiver C*-algebra and the C*-algebra of the corresponding 'quotient quiver'.

The intersection property of partial reduced crossed products

Larissa Kroell – *University of Waterloo*

Abstract: Given a C*-dynamical system, a fruitful avenue to study its properties has been to study the dynamics on its injective envelope. In particular, Kennedy and Schafhauser (2019) give a characterization of the ideal intersection property of a C*-dynamical system in terms of proper outerness of the group action on its G-injective envelope under some assumptions. In this talk, we generalize these techniques to partial C*-dynamical systems and show that if the system is properly outer, it exhibits the intersection property. In order to do so, we introduce the notion of an injective envelope for partial actions. This is joint work with Matthew Kennedy and Camila Sehnem.

Fundamental groupoids and universal covers of k-graphs and the associated C*-algebras

Alexander Kumjian – *University of Nevada, Reno*

Abstract: The fundamental groupoids and universal covers of k-graphs were introduced by Pask, Quigg and Raeburn nearly twenty years ago. They showed that the canonical map from a k-graph to its fundamental groupoid need not be injective. We show that the map is an embedding iff its universal cover embeds in its fundamental groupoid. We prove that the C*-algebra of the universal cover is AF and, if it embeds, it is a Fell algebra, that is, it is generated by ideals which are Rieffel-Morita equivalent to abelian C*-algebras. This talk will report on my joint work with Nathan Brownlowe, David Pask and Aidan Sims.

Upgraded free independence

Sri Kunnawalkam Elayavalli – *UCSD*

Abstract: I will describe a joint work with David Jekel wherein we discover a new degree of free independence phenomena in the ultrapower of free group factor. Various applications will be presented.

An index for quantum cellular automata

Junhwi Lim – *Vanderbilt University*

Abstract: The index for 1D quantum cellular automata (QCA) was introduced to measure the flow of the information by Gross, Nesme, Vogts, and Werner. Interpreting the index as the ratio of the Jones index for subfactors leads to a generalization of the index defined for QCA on a more general models. These include fusion spin chains, which arise as the local operators invariant under a global symmetry, and as the boundary operators on 2D topologically ordered spin systems. We introduce our generalization of index and show that it is a complete invariant for the group of QCA modulo finite depth circuits for the fusion spin chains built from the fusion category Fib. This talk is based on a joint work with Corey Jones.

The Curious Case of 2-Graph K-Theory

Joseph Lippert – *Sam Houston State University*

Abstract: In this talk, we will introduce the idea of higher-rank graphs and discuss how C* algebras can be built from their data. After this, we will use the Evans Chain Complex and the Kunneth Theorem to show that in many cases the K-groups of rank 2 graphs are isomorphic. We will conclude by extending parts of these results ranks higher than 2 and discussing further generalizations to a wider variety of 2-graphs.

C*-algebra theory in Lean

Jireh Loreaux – *Southern Illinois University Edwardsville*

Abstract: Lean is an interactive theorem prover and general purpose programming language. Within the language it is possible to state theorems formally and prove them, and Lean's kernel can verify their correctness. While there have historically been many proof assistants (Coq / Rocq, Mizar, Isabelle / HOL, Metamath, etc.), in recent years Lean has become quite popular and its mathematical library, Mathlib, has grown at a rapid pace. Lean has recently been used to formalize a number of high-profile results in various fields of mathematics.

This talk will cover our recent work on the formalization of C^*-algebra theory in Lean, especially the continuous functional calculus. This is, to our knowledge, the first attempt at the formalization of C^*-algebra theory in *any* proof assistant. This talk is meant to be an introduction to this subject and to formalization, and as such, no prior knowledge about Lean, formalization or proof assistants is assumed on the part of the audience.

Using Diagrams to Describe Quantum Symmetries of Subfactors

Melody Molander – *University of California, Santa Barbara*

Abstract: Classical objects such as vector spaces are highly symmetric, and the language of groups helps describe these symmetries. However, objects from quantum mechanics have more complex symmetries that can no longer be captured through group theory. These quantum symmetries instead require the language of higher categories. These categories are nice because they have a diagrammatic description called a planar algebra. Planar algebras used to describe quantum symmetries of subfactors were first constructed by Vaughan Jones. The Kuperberg Program asks to find all diagrammatic presentations of planar algebras describing subfactors. In this talk, I will introduce these planar algebras, describe how they capture quantum symmetry, and give generators and relations of some planar algebras of a particular class called "index 4".

Colored planar algebras for commuting squares and applications to Hadamard subfactors

Michael Montgomery – *Dartmouth College*

Abstract: In this talk we define a colored planar algebra associated to a non-degenerate commuting square and identify the biunitary of the square as an element of the planar algebra. We prove a variation of the graph planar algebra embedding theorem and use the biunitary to construct representations of annular algebras and quantum groups from the commuting square. When the commuting square subfactor is amenable we can compute elements in the spectrum of the principal graph of the subfactor. This leads to two criteria which imply non-flatness of the biunitary and infinite depth of the subfactor. Computations with these criteria are performed with a continuous family of biunitaries on the 3311 principal graph, Petrescu's continuous family of complex Hadamard matrices, and type II Paley Hadamard matrices. We conclude that all of Petrescu's complex Hadamard matrices and all type II Paley Hadamard matrices yield infinite depth subfactors.

Wavelet MRAs, Groupoid C^*-algebras, and Blaschke Composition Operators - Oh My! (Part 1)

Paul Muhly – *University of Iowa*

Abstract: This is the first part of a pair of talks on joint work with Marius Ionescu, who will give the second. Together, we outline new proofs of the main theorems in Stephane Mallat's famous *Multiresolution approximations and wavelet orthonormal bases of* $L_2(\boldsymbol{R})$. Our techniques, based on groupoid theory, extend to settings much more general than those

considered by Mallat. One of them involves composition operators on the unit circle that are generated by finite Blaschke products whose zeros are suitably constrained.

In Part 1, we show that given a surjective local homeomorphism σ of a 2^{nd}-countable, compact Hausdorff space X, it is possible to build a *blowup*, $G(X_\infty, \sigma_\infty)$, of the Deaconu-Renault groupoid based on σ, $G(X, \sigma)$, whose C^*-algebra, $C^*(G(X_\infty, \sigma_\infty))$, contains what we call a *proto-multi-resolution analysis* in its multiplier algebra, $M(C^*(G(X_\infty, \sigma_\infty)))$. The construction of $C^*(G(X_\infty, \sigma_\infty))$ involves a choice of Haar system on $G(X_\infty, \sigma_\infty)$. Thanks to work of Jean Renault, any two Haar systems yield Rieffel-Morita equivalent C^*-algebras. However, the one's important for wavelet theory are parameterized by the left inverses of the endomorphism of $C(X)$ induced by σ. Each left inverse is given by the formula $L^D(f)(x) := |\sigma^{-1}(x)|^{-1} \sum_{\sigma(y)=x} D(y)f(y)$, where D is a non-negative continuous function on X such that $L^D(1) = 1$. Such functions are called *normalized potentials* and these, in turn, may be used to build a system of measures $\{\nu^D_{\infty,x}\}_{x\in X}$, each of which is supported on X_∞. These, in further turn, are used to determine when certain induced representations of $C^*(G(X_\infty, \sigma_\infty))$ carry the proto-multi-resolution analysis to a bona fide (generalized) multi-resolution analysis and will be analyzed more thoroughly in Part 2. They lie at the heart of our analysis of wavelets. The upshot of Part 1 is that up to Rieffel-Morita equivalence, there is only one proto-multi-resolution analysis, and all Hilbert space MRAs are obtained through induced representations that will be revealed in Part 2.

Local factors and Cuntz-Pimsner algebras

Igor Nikolaev – *St. John's University*

Abstract: In this talk, we use K-theory of the Cuntz-Pimsner algebras to calculate the local factors (finite or infinite) of the Hasse-Weil zeta function of an arithmetic scheme. The problem of understanding the nature of the local factors at infinity in a conceptual way was raised by Serre and Deninger.

How to find Cartan subalgebras of twisted k-graph C^*-algebras

Rachael Norton – *St. Olaf College*

Abstract: Given a twisted C^*-algebra, it can be difficult (but also rewarding) to find a Cartan subalgebra, if one exists at all. However, if the C^*-algebra is generated by a groupoid G, then it is natural to look within G for a subgroupoid that gives rise to a Cartan subalgebra. In 2020, my collaborators and I identified sufficient conditions on a subgroupoid S so that the subalgebra generated by S is Cartan. In this talk, we focus on applications of the theorem to twisted k-graph C^*-algebras and present several examples of

the theorem in action. This is joint work with L. Gallagher, J. Briones Torres, S. Reznikoff, H. Vu, and S. Wright.

Local-Triviality Dimensions and Continuous Fields

Benjamin Passer – *United States Naval Academy*

Abstract: The local triviality dimensions of an action on a C*-algebra provide semi-invariants that are useful in noncommutative Borsuk-Ulam theory. I will discuss how these dimensions behave under continuous fields, drawing from examples related to noncommutative spheres, and clarify the relationship between freeness and finite-dimensionality of an action. Joint work with Alexandru Chirvasitu.

CB norms of k-positive maps

Vern Paulsen – *University of Waterloo*

Abstract: We study the problem of how large the completely bounded norm of a unital k-positive map can be when the range, respectively, domain, is a given operator system and the other operator system is arbitrary. Surprisingly, even for matrix algebras these values are not known. Given an operator system S, if we let $r_k(S)$ and $d_k(S)$ denote these values, then we prove that for finite dimensional operator systems, these values tend to one as k tends to infinity if and only if the operator system is exact or has the lifting property, respectively.

Obstructions to frame vectors and group representations

Gabriel Picioroaga – *University of South Dakota*

Abstract: We investigate existence of frame vectors associated to structured data, such as countable collections of isometries on a separable Hilbert space. In the case of unitary group representations we obtain a new characterization of amenability, and deduce a few properties in the spirit of (relative) property T. This is joint work with Catalin Georgescu.

Ergodic coactions and actions are the same

John Quigg – *Arizona State University*

Abstract: We will discuss a (true) special case of this absurd assertion. It involves coactions of compact groups on M_n. We show that every such coaction is associated with a Fell bundle, and is implemented by a unitary operator. We characterize when the coaction is inner, and when it is ergodic. We apply our techniques to show that the coaction can be effective and ergodic when the group is $SO(3)$, but not $SU(2)$.

Dirac operators for quantum Hamming metrics

Marc Rieffel – *U. C. Berkeley*

Abstract: Given the set of words of a given length for a given alphabet, the Hamming metric between two such words is the number of positions where the two words differ. A quantum version of Hamming metrics was introduced in 2021 by De Palma, Marvian, Trevisan and Lloyd. For the quantum version the alphabet is replaced by a full matrix algebra, and the set of words is replaced by the tensor product of a corresponding number of copies of that full matrix algebra. While De Palma et al. work primarily at the level of states, they do obtain the corresponding seminorm (the Hamming metric) on the algebra of observables that plays the roll of assigning Lipschitz constants to functions. A suitable such seminorm on a unital C*-algebra is the current common method for defining a quantum metric on a C*-algebra. In many important cases such seminorms can be obtained from spectral triples.

I will indicate how quantum Hamming metrics can be obtained from spectral triples, that is, from a representation of the C*-algebra on a Hilbert space together with a self-adjoint operator D on the Hilbert space such that the value of the seminorm on an element a of the algebra is given by the operator norm of the commutator $[D, a]$. One consequence of this is that the seminorm will be strongly Leibniz, i.e. satisfy a Leibniz inequality and more.

This is part of a project in progress.

On compactness of products of Toeplitz operators

Tomas Miguel Rodriguez – *University of Toledo*

Abstract: We study compactness of product of Toeplitz operators with symbols continuous on the closure of the polydisc in terms of behavior of the symbols on the boundary. For certain classes of symbols f and g, we show that $T_f T_g$ is compact if and only if fg vanishes on the boundary. We provide examples to show that for more general symbols,

the vanishing of fg on the whole polydisc might not imply the compactness of $T_f T_g$. On the other hand, the reverse direction is closely related to the zero product problem for Toeplitz operators on the unit disc, which is still open.

This is joint work with Trieu Le and Sönmez Şahutoğlu.

Deformations of Pure States by Continuous Selections of Unitaries

Daniel Spiegel – *University of California, Davis*

Abstract: Given a norm-continuous or weak*-continuous family of pure states of a unital C^*-algebra A, Michael's theory of continuous selections can be used to find norm-continuous families of unitaries that deform the states in various interesting ways. For example, the outputs of the Kadison transitivity theorem can be chosen to depend continuously on the inputs, so that the unitary group of A becomes a fiber bundle over each unitary equivalence class of pure states of A. For a weak*-continuous family of pure states and a projection $p \in A$, we give conditions that yield a homotopy of unitaries that deforms the family of states so that the entire family evaluates to one on p. This result can be iterated on with an excising sequence of projections to show that the space of pure states of a nonelementary, separable, simple, real rank zero C^*-algebra has trivial homotopy groups of all orders when equipped with the weak* topology.

Topological Stable Rank of F.D.C. Action

Xiaoyu Su – *Texas A&M University*

Abstract: Topological stable rank was first introduced by M. Rieffel in 1982, it can be seen as dimension of C*-algebra which directly generalizes the classical concept of dimension for compact spaces. More interestingly, topological stable rank can be used to control the matrix size of the K-theory element, which makes K-theory in some sense computable. I will be talking about one approach to calculate the topological stable rank of finite dynamical complexity (F.D.C.) system and explain the idea behind this quantitative method that mimics the idea of quantitative K-theory, in which case the associated C*-algebra could be simple. This is based on joint work with Bogdan Nica and Guoliang Yu.

Weak exactness and amalgamated free products of von Neumann algebras

Kai Toyosawa – *Vanderbilt University*

Abstract: Weak exactness for von Neumann algebras was first introduced by Kirchberg in 1995 as an analogue of exactness in the setting of C*-algebras. In this talk, I will show that the amalgamated free product of weakly exact von Neumann algebras is again weakly exact. The proof involves a universal property of Toeplitz-Pimsner algebras and a locally convex topology on bimodules of von Neumann algebras, which is used to characterize weak exactness.

C*-algebras of one-sided subshifts over arbitrary alphabets.

Daniel van Wyk – *Fairfield University*

Abstract: Shift spaces and their subshifts are central objects in the study of symbolic dynamics. Up to isomorphism, certain C*-algebras form invariants for shift conjugacy of subshifts over finite alphabets. Ott, Tomforde, and Willis proposed a subshift over an infinite alphabet that circumvents topological obstructions in the usual construction. Applying their subshift construction to the edge shifts of directed graphs, they show that if the edge shifts conjugate, then the C*-algebras of the graphs are isomorphic. A natural question is whether there is C*-algebra associated with their subshift, which is an invariant in general, analogous to finite alphabet subshifts.

This talk introduces a C*-algebra O_X associated with a one-sided subshift X over an arbitrary alphabet. The C*-algebra O_X (and related data) is a complete invariant for topological conjugacy of Ott, Tomforde, and Willis' subshifts. For countable alphabets, O_X is an invariant for isometric conjugacy of subshifts with the product metric. Furthermore, for a suitable partial action associated with a subshift over a countable alphabet, this C*-algebra is also an invariant for continuous orbit equivalence.

Joint with Giuliano Boava, Gilles G. de Castro, and Daniel Gonçalves.

Entropic Inequalities on Compact Lie Groupoids

Vincent Villalobos – *University of Illinois at Urbana-Champaign*

Abstract: We will look at entropic inequalities developed for quantum Markov semigroups on von Neumann algebra and the tools developed for obtaining said inequalities. Marius Junge and others developed the complete modified log Sobolev inequality (CLSI) for von Neumann algebras. This particular inequality has many desirable characteristics, mainly the feature of tensor stability, something that previous spectral gap inequalities

fail. The main focus of the talk will be to examine a tool in obtaining this inequality called the "transference principle" and its recent development and application to compact Lie groupoids.

Boundary algebras and Kitaev's quantum double model

Daniel Wallick – *Ohio State University*

Abstract: Topologically ordered quantum spin systems have become an area of great interest, in part because the ground state space for these systems is a quantum error-correcting code. This is reflected in the axiomatization of topological order given by Bravyi, Hastings, and Michalakis. In this talk, we will describe new local topological order axioms given in joint work with Corey Jones, Pieter Naaijkens, and David Penneys. These axioms strengthen those of Bravyi, Hastings, and Michalakis, and they give rise to a 1-dimensional net of boundary algebras. We provide an example satisfying these axioms, namely Kitaev's quantum double model. In joint work with Mario Tomba, Shuqi Wei, Brett Hungar, Chian Yeong Chuah, Kyle Kawagoe, and David Penneys, we compute the boundary algebras for this model and show that they give nets of algebras corresponding to either $\mathrm{Hilb}(G)$ or $\mathrm{Rep}(G)$ depending on whether the boundary is rough or smooth. In either case, the inductive limit of the boundary algebras is $M_{|G|^\infty}$ and we have a canonical state on the boundary algebra which is tracial.

The Spectrum of C^*-algebras Arising from Crystallography Groups

Ellen Weld – *Sam Houston State University*

Abstract: Crystallography groups are discrete cocompact subgroups of isometries of Euclidean space and have been studied by chemists, physicists, and mathematicians alike. Mackey's machine provides a set theoretic description of irreducible representations of C^*-algebras arising from crystallography groups but practically computing these representations is tricky. In this talk, we discuss an algorithm for systematically computing representations while also exploring the topology of the spectrum. Joint work with Frankie Chan.

Dynamical Cuntz Semigroups and Almost Elementary C*-Dynamical Systems

Joachim Zacharias – *University of Glasgow*

Abstract: Motivated by the Toms-Winter conjecture and Kerr's dynamical version of this conjecture for actions of amenable discrete groups on compact metric spaces, we develop a dynamical version of the Cuntz semigroup, allowing us to define dynamical strict comparison, and the concept of almost elementary actions on general C*-algebras which we think of as dynamical $\mathcal{Z}$-stability. The dynamical Cuntz semigroup requires a new type of quotient taken on the level of relations. Almost elementariness is a simultaneous approximation property of the algebra and the action, up to an arbitrarily small remainder in a dynamically tracial sense. It turns out that various different natural smallness of remainder conditions are all equivalent. In case of commutative coefficients almost elementariness is equivalent to almost finiteness; in case of no group action dynamical comparison is the usual Cuntz comparison whereas almost elementariness is equivalent to $\mathcal{Z}$-stability for separable simple nuclear algebras. Almost elementary actions lead to $\mathcal{Z}$-stable crossed products. Many of our results apply to actions on non-simple algebras.

This is joint work with Joan Bosa, Francesc Perera and Jianchao Wu.

Norming for Discrete Crossed Products

Vrej Zarikian – *United States Naval Academy*

Abstract: In this talk, based on joint work with David Pitts and Roger Smith, we continue to investigate the relationship between two "largeness" conditions for C^*-inclusions: uniqueness of pseudo-expectations and norming.

- A **pseudo-expectation** for a C^*-inclusion $\mathcal{A} \subseteq \mathcal{B}$ is a UCP (unital completely positive) map $\theta : \mathcal{B} \to I(\mathcal{A})$ such that $\theta(a) = a$ for all $a \in \mathcal{A}$. Here $I(\mathcal{A})$ is the injective envelope of $\mathcal{A}$. Pseudo-expectations generalize conditional expectations, but are always guaranteed to exist.
- The C^*-inclusion $\mathcal{A} \subseteq \mathcal{B}$ is **norming** if

$$(\forall\ X \in M_n(\mathcal{B}))\ \|X\| = \sup\{\|RXC\| : R \in \text{Ball}(\text{Row}_n(\mathcal{A})),\ C \in \text{Ball}(\text{Col}_n(\mathcal{A}))\}.$$

  That is, norms of matrices over $\mathcal{B}$ can be computed by pre- and post-multiplying by contractive rows and columns over $\mathcal{A}$, respectively.

Pitts showed that for regular MASA inclusions, having a <u>faithful</u> unique pseudo-expectation implies norming. Although there are examples of non-norming C^*-inclusions with a faithful unique pseudo-expectation, it remains open whether there are <u>separable</u> examples. Among

other results, we prove that if $\mathcal{A}$ is separable and $G \curvearrowright \mathcal{A}$ is a discrete group action, then the C^*-inclusion $\mathcal{A} \subseteq \mathcal{A} \rtimes_r G$ is norming provided it has a faithful unique pseudo-expectation.

Perturbations of Representations of Cartan Inclusions

Catherine Zimmitti – *University of Nebraksa-Lincoln*

Abstract: In 2005, Charles Read constructed an interesting yet mysterious example of a free semigroup algebra that is a von Neumann algebra; this construction was later simplified by Ken Davidson. The construction involves taking a standard representation of $\mathcal{O}_2$ and multiplying it by a certain unitary operator in the diagonal MASA of the representation, creating a new "perturbed" representation of $\mathcal{O}_2$. We explore this notion of perturbed representations in the more general setting of Cartan inclusions.