



UNIVERSITY OF PUERTO RICO AT RIO PIEDRAS

# SYMPOSIUM ON K-THEORY AND NON-COMMUTATIVE TOPOLOGY 2018

OCTOBER 21-26, 2018

Invited speakers

Michael Brannan, Nate Brown, Sarah Browne, José Carrión, Caleb Eckhardt, Eric Guentner, Chunlan Jiang, Marius Junge, Mehrdad Kalantar, Hanfeng Li, Huaxin Lin, Tao Mei, Zhuang Niu, Cornel Pasnicu, Chris Phillips, Lin Shan, Yanli Song, Xiang Tang, Iván Velázquez, Kun Wang, Rufus Willett, Zhizhang Xie, Guoliang Yu

Sponsored by



Organizing Committee:

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Guihua Gong (University of Puerto Rico, Río Piedras),  
Liangqing Li (University of Puerto Rico, Río Piedras),  
Lin Shan (University of Puerto Rico, Río Piedras),  
Xiang Tang (Washington University in St. Louis),  
Guoliang Yu (Texas A&M University)

Secretaries:

Iván Velázquez (University of Puerto Rico, Río Piedras),  
Kun Wang (Texas A&M University)

Schedule of the Symposium on K-Theory and Noncommutative Topology				
10/22/18		10/23/18	10/24/18	10/25/18
8:00-8:50	Chancellor/Dean/Chair (8:15-8:30 am)	Hanfeng Li	Chris Phillips	Nate Brown (8:30-9:20 am)
9:00-9:50 am	Guoliang Yu (8:30-9:20 am)			
	Rufus Willett (9:30-10:20 am)	Zhuang Niu	Tao Mei	Marius Junge (9:30-10:20 am)
Tea Break 9:50-10:10 am	Tea Break 10:20-10:50 am	Tea Break 9:50-10:10 am	Tea Break 9:50-10:10 am	Tea Break (10:20-10:50 am)
10:10-11:00	Huaxin Lin (10:50-11:40 am)	Kun Wang	Zhizhang Xie	Michael Brannan (10:50--11:40 am)
11:10-12:00		Cornel Pasnicu	Mehrdad Kalantar	
Lunch Break	Lunch Break	Lunch Break	Lunch Break	Lunch Break
2:30-3:20	Yanli Song		Chunlan Jiang (2:00-2:50 pm)	Xiang Tang
3:30-4:20	Jose Carrion		Caleb Eckhardt (3:00-3:50 pm)	Eric Guentner
Tea Break 4:20-4:50	Tea Break 4:20-4:50		Tea Break 3:50-4:10	Tea Break 4:20-4:50
4:50-5:40	Lin Shan		Sarah Browne (4:10-5:00 pm)	Ivan Velazquez
5:30-8:00pm			Dinner at Chancellor's House (5:30-8:00 pm)	



# Contents

<b>Monday, October 22, 2018</b>	<b>1</b>
K-theory of operator algebras associated to groups ( <i>Guoliang Yu</i> ) . . . . .	2
Controlled K-theory, decompositions, and the Künneth formula ( <i>Rufus Willett</i> ) .	3
Simple stably projectionless C*-algebras ( <i>Huaxin Lin</i> ) . . . . .	4
An equivariant index theorem on non-compact manifolds and Kasparov product ( <i>Yanli Song</i> ) . . . . .	5
A von Neumann-algebraic approach to the classification of C*-algebras ( <i>José R. Carrión</i> ) . . . . .	6
The concentration property of expanders and group extension ( <i>Lin Shan</i> ) . . . .	7
<b>Tuesday, October 23, 2018</b>	<b>9</b>
Bivariant Sylvester rank functions ( <i>Hanfeng Li</i> ) . . . . .	10
Comparison radius of the C*-algebra of a minimal homeomorphism ( <i>Zhuang Niu</i> )	11
Classification of C*-algebras and its invariant ( <i>Kun Wang</i> ) . . . . .	12
The weak ideal property and topological dimension zero ( <i>Cornel Pasnicu</i> ) . . . .	13
<b>Wednesday, October 24, 2018</b>	<b>15</b>
Nonunital tracially Z-stable C*-algebras ( <i>Chris Phillips</i> ) . . . . .	16
Hilbert Transforms on Free Groups ( <i>Tao Mei</i> ) . . . . .	17
Higher rho invariants and pairings with higher dimensional cyclic cocycles ( <i>Zhizhang Xie</i> ) . . . . .	18
Stationary states and their applications to C*-simplicity problems ( <i>Mehrdad Kalantar</i> ) . . . . .	19
Classification for the AH algebras with ideal property ( <i>Chunlan Jiang</i> ) . . . . .	20
C*-rigidity of two-step nilpotent groups ( <i>Caleb Eckhardt</i> ) . . . . .	21
Quantitative E-theory ( <i>Sarah L. Browne</i> ) . . . . .	22
<b>Thursday, October 25, 2018</b>	<b>23</b>
C*-structure and the UCT ( <i>Nate Brown</i> ) . . . . .	24
Towards an index theorem for noncommutative, noncompact spaces ( <i>Marius Junge</i> )	25
Quantum permutations and their matrix models ( <i>Michael Brannan</i> ) . . . . .	26
A longitudinal index theorem on an open foliation manifold ( <i>Xiang Tang</i> ) . . . .	27
Hyperbolicity, Dirichlet functions and affine actions ( <i>Eric Guentner</i> ) . . . . .	28
The exponential length of the commutator subgroup of the unitary group of Goodearl algebras ( <i>Iván Velázquez</i> ) . . . . .	29
<b>Author Index</b>	<b>31</b>



**Monday, October 22, 2018**

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# K-theory of operator algebras associated to groups

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October 12, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

I will discuss K-theory of Banach and  $C^*$ -algebras associated to groups and applications to geometry, topology, and representation theory.

Monday  
October 22  
8:30am

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## Controlled K-theory, decompositions, and the Künneth formula

Rufus Willett  
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October 19, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

I will discuss some approaches to proving the Künneth formula via controlled K-theory. The rough idea (due to Oyono-Oyono and Yu) is that one wants to decompose a  $C^*$ -algebra into 'approximate' ideals, and then use 'approximate' Mayer-Vietoris sequences to deduce K-theoretic results. I will explain some of this, and also how assumptions on nuclear dimension get one close to the relevant 'approximate' ideal structure.

Monday  
October 22  
9:30am

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## Simple stably projectionless $C^*$ -algebras

Huaxin Lin  
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October 18, 2018



SYMPOSIUM ON  $K$ -THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

Simple stably projectionless  $C^*$ -algebras

Monday  
October 22  
10:50am

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# An equivariant index theorem on non-compact manifolds and Kasparov product

Yanli Song  
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October 12, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

Braverman introduced an index theorem for a non-compact manifold using a Dirac operator and a vector field which has a compact vanishing set. In this talk, I will discuss a KK-theory approach to Braverman's index theory. In this framework, we can prove a generalized version of cobordism invariance of index on non-compact manifolds.

Monday  
October 22  
2:30pm

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# A von Neumann-algebraic approach to the classification of $C^*$ -algebras

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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

We report on a joint project with James Gabe, Christopher Schafhauser, Aaron Tikuisis, and Stuart White that aims to provide a new abstract approach the classification of simple nuclear  $C^*$ -algebras.

Monday  
October 22  
3:30pm

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# The concentration property of expanders and group extension.

Lin Shan  
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October 12, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

In this talk, we will discuss the concentration property of expanders into Hadamard manifolds and its application to the coarse embedding into group extensions.

Monday  
October 22  
4:50pm



**Tuesday, October 23, 2018**

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## Bivariant Sylvester rank functions

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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

For a unital ring  $R$ , a Sylvester rank function assigns a nonnegative real number (the rank) to each rectangular matrix over  $R$ , or equivalently, to each finitely presented left  $R$ -module. The Sylvester rank functions play a vital role in the proof of Kaplansky's direct finiteness conjecture for sofic groups,  $L^2$ -invariants theory, and classification program for  $C^*$ -algebras. I will discuss how to extend each Sylvester rank function to a bivariant one for pairs  $(A, B)$  with  $A$  being a submodule of any left  $R$ -module  $B$ , and give some applications of this extension.

Tuesday  
October 23  
8:00am

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# Comparison radius of the $C^*$ -algebra of a minimal homeomorphism

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October 19, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

Consider a free minimal homeomorphism of a compact metrizable space. It is shown that the comparison radius of the crossed product  $C^*$ -algebra is at most half of the topological mean dimension of the given homeomorphism.

*Keywords:* Cuntz semigroup, comparison radius, mean dimension

Tuesday  
October 23  
9:00am

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# Classification of $C^*$ -algebras and its invariant

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October 12, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

In this talk, I will introduce different kinds of invariant for classification of  $C^*$ -algebras, such as the Elliott invariant, extended Elliott invariant, Stevens invariant,  $\text{inv}_0(\cdot)$  and  $\text{inv}(\cdot)$ . I will show some classification results to let you know how powerful those invariants are. Furthermore, I will study the relation between those invariant.

The extended Elliott invariant contains the Elliott invariant and all extended valued traces. It characterizes the ideal structure of  $C^*$ -algebras. I will show that the extended Elliott invariant and Stevens invariant are equivalent when we consider stably finite  $C^*$ -algebras with the ideal property. For invariants  $\text{inv}_0(\cdot)$  and  $\text{inv}(\cdot)$ , where the former is a subset of the latter, I will show that they are equivalent for AH-algebras with finitely many ideals.

*Keywords:* Classification,  $C^*$ -algebra, ideal property, Elliott invariant

## References

- [1] C. Jiang, K. Wang, A complete classification of limits of splitting interval algebras with the ideal property, *J. Ramanujan Math. Soc.* 27, No.3 (2012) 305-354.
- [2] Q. Pan, K. Wang, About the bound of the  $C^*$  exponential length, *Canadian Mathematical Bulletin* 57(2014), no. 4, 853-869. <http://dx.doi.org/10.4153/CMB-2014-044-8>
- [3] K. Wang, Equivalence of two Invariants of  $C^*$ -algebras with the ideal property, accepted by Journal of Noncommutative Geometry.

Tuesday  
October 23  
10:10am

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# The weak ideal property and topological dimension zero

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SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

October 12, 2018

## Abstract

Following up on previous work, we prove a number of results for  $C^*$ -algebras with the weak ideal property or topological dimension zero, and some results for  $C^*$ -algebras with related properties. Some of the more important results include:

Tuesday  
October 23  
11:10am

- The weak ideal property implies topological dimension zero.
- For a separable  $C^*$ -algebra  $A$ , topological dimension zero is equivalent to  $\text{RR}(\mathcal{O}_2 \otimes A) = 0$ , to  $D \otimes A$  having the ideal property for some (or any) Kirchberg algebra  $D$ , and to  $A$  being residually hereditarily in the class of all  $C^*$ -algebras  $B$  such that  $\mathcal{O}_\infty \otimes B$  contains a nonzero projection.
- Extending the known result for  $\mathbb{Z}_2$ , the classes of  $C^*$ -algebras with residual (SP), which are residually hereditarily (properly) infinite, or which are purely infinite and have the ideal property, are closed under crossed products by arbitrary actions of abelian 2-groups.
- If  $A$  and  $B$  are separable, one of them is exact,  $A$  has the ideal property, and  $B$  has the weak ideal property, then  $A \otimes_{\min} B$  has the weak ideal property.
- If  $X$  is a totally disconnected locally compact Hausdorff space and  $A$  is a  $C_0(X)$ -algebra all of whose fibers have one of the weak ideal property, topological dimension zero, residual (SP), or the combination of pure infiniteness and the ideal property, then  $A$  also has the corresponding property (for topological dimension zero, provided  $A$  is separable).
- Topological dimension zero, the weak ideal property, and the ideal property are all equivalent for a substantial class of separable  $C^*$ -algebras including all separable locally AH algebras.
- The weak ideal property does not imply the ideal property for separable  $Z$ -stable  $C^*$ -algebras.

We give other related results, as well as counterexamples to several other statements one might hope for.

This is joint work with N. Christopher Phillips and it appeared in the *Canad. J. Math.* 2017.



**Wednesday, October 24, 2018**

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## Nonunital tracially Z-stable $C^*$ -algebras

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October 12, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

We define tracial Z-stability for nonunital simple  $C^*$ -algebras, and prove some properties of nonunital tracially Z-stable  $C^*$ -algebras. Some properties and results are new even in the unital case. For example, we give unital tracially Z-stable  $C^*$ -algebras which are not Z-stable, and we show that the action of the symmetric group on an  $n$ -fold minimal tensor product of tracially Z-stable  $C^*$ -algebras has the appropriate (nonunital) version of the weak tracial Rokhlin property (using comparison, not traces) whenever the tensor product is finite.

This is joint work with Massoud Amini, Nasser Golestani, and Saeid Jamali.

Wednesday  
October 24  
8:00am

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# Hilbert Transforms on Free Groups

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October 12, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

Let  $\mathbb{F}_\infty$  be the free group with free generators  $g_1, g_2, \dots$ . Let  $\mathcal{L}_{g_i}^+, \mathcal{L}_{g_i}^-$  be the subsets of  $\mathbb{F}_\infty$  of reduced words starting respectively with  $g_i, g_i^{-1}$ . Let  $L_{g_i}^\pm$  be the projection onto  $\lambda(\mathcal{L}_{g_i}^\pm)$  with  $\lambda$  the left regular representation of  $\mathbb{F}_\infty$ .

The following map is a free analogue of the classical Hilbert transform <sup>1</sup>

$$H_\varepsilon = \varepsilon_1 L_{g_1}^+ + \varepsilon_{-1} L_{g_1}^- + \varepsilon_2 L_{g_2}^+ + \varepsilon_{-2} L_{g_2}^- + \dots$$

for  $\varepsilon_i = \pm 1$ . P. Biane and G. Pisier asked the question whether  $H_\varepsilon$  is bounded on the noncommutative  $L^p$  space  $L^p(\hat{\mathbb{F}}_\infty)$  for all  $1 < p < \infty$ . Joint with E. Ricard, we answered this question positively in [1].

Very recently, in a joint work with Q. Xu, we further study the class of Fourier multipliers sending

$$\lambda_g \mapsto m(g)\lambda_g$$

with  $m(g)$  a scalar depending merely on the first block in the reduced word, and give a characterization on the complete boundedness of these Fourier multipliers on  $L^p(\hat{\mathbb{F}}_\infty)$ . A Dirac operator on free groups plays an essential role in the proof.

**Keywords:** Free Groups, Noncommutative  $L^p$ -spaces, Hilbert Transforms, Completely Bounded Map

## References

- [1] T. Mei, E. Ricard, Free Hilbert transforms, *Duke Mathematical Journal*, 166 (2017), no. 11, 2153-2182.
- [2] T. Mei, Q. Xu, A Mikhlin Multiplier Theory for Free Groups, preprint.

<sup>1</sup>Hilbert transform had appeared in the work of Arverson and the work of Voiculescu with different point of views.

Wednesday  
October 24  
9:00am

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## Higher rho invariants and pairings with higher dimensional cyclic cocycles

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SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

October 12, 2018

### Abstract

Wednesday  
October 24  
10:10am

In this talk, I will discuss precise connections between the Higson-Roe's higher rho invariants and Lott's higher eta invariants. In my joint work with Guoliang Yu, we showed that the pairing of delocalized traces (i.e. traces determined conjugacy classes away from the identity element) and a higher rho invariant is equal to Lott's delocalized eta invariant, under the assumption that the corresponding conjugacy class has polynomial growth. In the language of cyclic cohomology, the above pairing is simply the pairing between higher rho invariants and 0-dimensional cyclic cocycles of the group algebra. My student Sheagon John extended the above pairing to higher dimensional cyclic cocycles for groups that have polynomial growth. In my recent joint work with Jinmin Wang and Guoliang Yu, we extend this pairing to higher dimensional cyclic cocycles for hyperbolic groups.

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## Stationary states and their applications to $C^*$ -simplicity problems

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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

We introduce the notion of stationary states on  $C^*$ -algebras, and give some applications in simplicity problems of crossed product  $C^*$ -algebras. This is based on joint works with Yair Hartman, and Tattwamasi Amrutam.

Wednesday  
October 24  
11:10am

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## Classification for the AH algebras with ideal property

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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

In this talk, we give a completely isomorphism invariants of AH algebras with ideal property by using K-theory; Hausdorffized  $K_1$ -group and trace space.

Wednesday  
October 24  
2:00pm

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## $C^*$ -rigidity of two-step nilpotent groups

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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

(Joint work with Sven Raum) We examine the following classic question—Does a group ring remember its generating group?—from a  $C^*$ -algebraic perspective. A group  $G$  is called  $C^*$ -superrigid if  $C_r^*(G) \cong C_r^*(H)$  implies  $G \cong H$  for any other group  $H$ . It has long been known that torsion free abelian groups are  $C^*$ -superrigid because such a group  $G$  is recovered as the quotient of the unitary group of  $C^*(G)$  by the connected component of the identity. Beyond abelian groups very little was known about  $C^*$ -superrigid groups. The “next” natural class of groups to consider are the nilpotent ones. In this talk I will discuss a recent result with S. Raum that shows finitely generated two-step nilpotent groups are  $C^*$ -superrigid.

Wednesday  
October 24  
3:00pm

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## Quantitative E-theory

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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

Quantitative E-theory is an ongoing project joint with Nate Brown which aims to create a new approach to tackling results like the Universal Coefficient Theorem (UCT) for new classes of  $C^*$ -algebras. In recent years, many people have been working on classifying  $C^*$ -algebras and these results assume the UCT, which requires further understanding. The inspiration is work by Oyono-Oyono-Yu, who used a quantitative approach of K-theory to prove the K nneth Theorem for new classes of  $C^*$ -algebras. An ongoing project of Willett-Yu extends the quantitative approach to the KK-context. Quantitative E-theory is a generalisation of E-theory and so I will begin my talk by defining the notion of E-theory and talk about how we get the definition of Quantitative E-theory. Then I will state results connecting this definition to E-theory and the UCT.

Wednesday  
October 24  
4:10pm

**Thursday, October 25, 2018**

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## $C^*$ -structure and the UCT

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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

In 2015 a monumental classification theorem was proved, following decades of work by dozens of researchers. The final ingredients, appearing in papers by Elliott/Gong/Lin/Niu and Tikuisis/White/Winter, bridged a gap between a broad classification theorem and a powerful reduction theorem. This bridge was built on a deep understanding of the structure of nuclear  $C^*$ -algebras. We believe a similar bridge is ready to be built in the context of the UCT. In this talk I'll discuss how recent advances in the theory of quantitative K-theory and K-homology, together with  $C^*$ -structure theorems inspired by topological and asymptotic dimension, suggest it's time to adapt the template used in Elliott's classification program for a full assault on the UCT.

Thursday  
October 25  
8:30am

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## Towards an index theorem for noncommutative, noncompact spaces

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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

In a modest attempt to understand some aspects of noncommutative geometry, my coauthor Li Gao and I tried to write down the content of the famous Connes-Skandalis index theorem for noncommutative versions of  $\mathbb{R}^n$ , called Moyal Plane or Instanton Algebras. These are examples of noncommutative, noncompact manifolds. Despite the similarity with  $\mathbb{R}^n$ , reducing the index formulae to one remotely resembling the case of manifolds appears to be a non-trivial task which requires a fair amount of theory of pseudodifferential operators. I will explain how this connects to noncommutative harmonic analysis, and how a natural choice of noncommuting vector fields leads to an expression resembling a B field. If time and the organizers permit, I will also share my experience on an IGL (Illinois Geometry Lab) Project for Undergraduates on Noncommutative Geometry.

This is joint work with Li Gao (Texas A& M) and Ed McDonald (UNSW).

Thursday  
October 25  
9:30am

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## Quantum permutations and their matrix models

Michael Brannan  
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SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

October 18, 2018

### Abstract

Thursday  
October 25  
10:50am

A quantum permutation matrix is an  $N \times N$  matrix  $P$  whose entries are orthogonal projections on a Hilbert space  $H$  with the property that the rows and columns of  $P$  sum to the identity operator on  $H$ . In the special case where  $H$  is the one dimensional Hilbert space, a quantum permutation matrix is simply an ordinary permutation matrix, and can be thought of as describing a symmetry of an  $N$  point set. In this talk I will explain how arbitrary quantum permutation matrices describe the "quantum symmetries" of an  $N$  point set. Putting all of these quantum permutation matrices together in a cohesive way yields the structure of a quantum group, which is commonly called the Quantum Permutation Group on  $N$  letters. Unlike the classical permutation groups, quantum permutation groups turn out to be highly infinite and noncommutative objects – in many ways they behave algebraically like the  $C^*$ - and von Neumann algebras associated to nonabelian free groups. Despite their inherent infiniteness, I will show how quantum permutation groups can still be well-approximated by finite-dimensional structures. In particular, these objects turn out to be residually finite as discrete quantum groups, and this residual finiteness can in fact be achieved using very simple finite-dimensional matrix models which I will describe. (Joint work with Alexandru Chirvasitu and Amaury Freslon.)

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## A longitudinal index theorem on an open foliation manifold

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October 12, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

### Abstract

In this talk, we will introduce the concept of Roe  $C^*$ -algebra for a locally compact groupoid whose unit space is in general not compact, and that is equipped with an appropriate coarse structure and Haar system. Using Connes' tangent groupoid method, we will define an analytic index for an elliptic differential operator on a Lie groupoid equipped with additional metric structure, which takes values in the K-theory of the Roe  $C^*$ -algebra. And we will discuss applications of our developments to longitudinal elliptic operators on an open foliated manifold. This is joint work with Rufus Willett and Yi-Jun Yao.

Thursday  
October 25  
2:30pm

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# Hyperbolicity, Dirichlet functions and affine actions

Eric Guentner  
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October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

Hyperbolicity, Dirichlet functions and affine actions

Thursday  
October 25  
3:30pm

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# The exponential length of the commutator subgroup of the unitary group of Goodearl algebras

Iván Velázquez  
University of Puerto Rico, Río Piedras

October 18, 2018



SYMPOSIUM ON K-THEORY AND  
NON-COMMUTATIVE TOPOLOGY

## Abstract

We calculate the  $C^*$ -exponential length of the commutator subgroup of the unitary group for the class of Goodearl algebras with real rank one over simplicial complexes with dimension greater than or equal to one.

Thursday  
October 25  
4:50pm



# Author Index

Brannan Michael, 26  
Brown Nate, 24  
Browne Sarah L., 22

Carrión José R., 6

Eckhardt Caleb, 21

Guentner Eric, 28

Jiang Chunlan, 20  
Junge Marius, 25

Kalantar Mehrdad, 19

Li Hanfeng, 10  
Lin Huaxin, 4

Mei Tao, 17

Niu Zhuang, 11

Pasnicu Cornel, 13  
Phillips Chris, 16

Shan Lin, 7  
Song Yanli, 5

Tang Xiang, 27

Velázquez Iván, 29

Wang Kun, 12  
Willett Rufus, 3

Xie Zhizhang, 18

Yu Guoliang, 2