

Programme on  
“Bivariant K-theory in Geometry and Physics”

November 5 - 30, 2018

organized by

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Conference

November 26 - 30, 2018

All talks take place in the Boltzmann Lecture Hall.

• Monday, November 26, 2018

**09:00 – 09:30 Registration**

**09:30 – 10:30**

**Speaker:** Guo Chuan Thiang

**Title:** Crystallographic T-duality and super Baum-Connes conjecture

**Abstract:** A relatively unexplored direction for the Baum-Connes conjecture is that for super-groups. As an example, the footprints generated from walking in a straight line has graded symmetry group the integers with the even-odd grading: the graded K-theory of the group algebra is isomorphic to the twisted K-homology of the classifying space, and both already have 2-torsion. This is one example in a whole zoo of crystallographic T-dualities, uncovered recently with my collaborator K. Gomi, which had been anticipated from string theory and the physics of topological matter.

10:30 – 11:00 *Coffee / Tea Break*

**11:00 – 12:00**

**Speaker:** Christopher Max

**Title:** Bulk-boundary Correspondence of Disordered Topological Insulators and Superconductors

**Abstract:** We construct explicit classes in real K-theory for the gapped bulk and the gapless boundary of a topological insulator or superconductor with homogeneous disorder. We prove a bulk-boundary correspondence including disorder for all complex and real Altland-Zirnbauer classes. The explicit form of our constructions enables us to derive several properties of the bulk-boundary correspondence using bivariant K-theory. This is joint work with A. Alldridge.

12:00 – 15:00 *Lunch Break*

15:00 – 15:30 *Coffee / Tea Break*

**15:30 – 16:30**

**Speaker:** Francesca Arici

**Title:** Gysin exact sequences from Cuntz–Pimsner extensions.

**Abstract:** Gysin exact sequences for sphere bundles play a crucial role in mathematical physics, notably in the study of T-duality and Chern Simons theory on Seifert-manifolds. In this talk, I will concentrate on operator algebraic versions of this exact sequence. I will start by recalling how Pimsner algebras of self-Morita equivalences can be thought of as total spaces of quantum circle bundles, and the associated six term exact sequence in K-theory can be interpreted as an operator algebraic version of the classical Gysin sequence

for circle bundles. After that, I will review how the extension class for Cuntz–Pimsner algebras allow us to relate this exact sequence to the mapping cone exact sequence. If time allows, I will report on work in progress concerning the construction of higher dimensional quantum sphere bundles in terms of Cuntz–Pimsner algebras of sub-product systems.

- **Tuesday, November 27, 2018**

**09:30 – 10:30**

**Speaker:** Johannes Kellendonk

**Title:** Secondary invariants for real K-theory from cyclic cohomology.

**Abstract:** The K-theoretical classification of topological phases provides many interesting cases in which there are elements of finite order. For instance, the strong invariant for two- or three-dimensional systems with time reversal symmetry corresponds to the generator of a  $\mathbb{Z}/2$ . There are various proposals to associate to such abstract K-theory elements numerical values, that is, complex numbers modulo something. We present here a construction which does precisely this on the basis of secondary pairings between K-theory and cyclic cohomology. As a result the numerical invariants will be formulated through integral formulas which are similar to those for the standard chern numbers but involve an extra symmetry operator, either of spin, or of chiral symmetry type.

10:30 – 11:00 *Coffee / Tea Break*

**11:00 – 12:00**

**Speaker:** Chris Bourne

**Title:** Notes on Kitaev's  $\mathbb{Z}_2$  index for Majorana fermions

**Abstract:** In 2000, Kitaev constructed a simple model of a superconducting wire and defined a  $\mathbb{Z}_2$  index associated to the ground state. I will briefly review this construction and its connection to exactly solved models, Araki's work on Bogoliubov transformations and the  $\mathbb{Z}_2$ -valued spectral flow introduced by Carey, Phillips and Schulz-Baldes. We also consider extensions of Kitaev's model to include quartic interactions and so can begin to probe the topological phase of a many-body ground state. This is work in progress with Hermann Schulz-Baldes.

12:00 – 15:00 *Lunch Break*

15:00 – 15:30 *Coffee / Tea Break*

**15:30 – 16:30**

**Speaker:** Valerio Proietti

**Title:** K-theory and homology in hyperbolic dynamics.

**Abstract:** We will look at Smale spaces, a class of dynamical systems introduced by Ruelle as a topological version of Smale's Axiom A diffeomorphisms. Putnam has introduced a homology theory for these systems, and an interesting problem is relating these groups to the K-groups for the associated  $C^*$ -algebras. I will introduce a variant of Putnam's theory for which this relation can be established by exploiting the triangulated structure of the (equivariant) KK-category.

- **Wednesday, November 28, 2018**

**09:30 – 10:30**

**Speaker:** Koen van Den Dungen

**Title:** The Kasparov product on submersions of open manifolds

**Abstract:** I will discuss the unbounded Kasparov product of first-order differential operators on (possibly non-compact and incomplete) Riemannian manifolds. Specifically, I will show that, on a submersion of Riemannian manifolds, the tensor sum of a regular vertically elliptic operator on the total space and an elliptic operator on the base space represents the Kasparov product of the corresponding classes in KK-theory. The proof uses a version of Kucerovsky's theorem for half-closed modules, which allows us to deal with symmetric but non-self-adjoint operators. The assumption of regularity for the vertically elliptic operator is not always satisfied, and I give explicit examples of both regular and non-regular operators. The main result is then used to obtain a factorisation in unbounded KK-theory of the Dirac operator on a Riemannian submer-

sion (generalising recent work by Kaad and Van Suijlekom on proper Riemannian submersions).

10:30 – 11:00 *Coffee / Tea Break*

**11:00 – 12:00**

**Speaker:** Victor Gayral

**Title:** A class of locally compact quantum groups arising from Kohn–Nirenberg quantization

**Abstract:** Locally compact quantum group (LCQG) in the setting of von Neumann algebras (aka Kustermans–Vaes quantum groups), is believed to give the correct notion of symmetries of quantum spaces (in the setting of operator algebras). While this theory is fast growing, there is very few examples of (non-compact) LCQG. In this talk, I will explain how the good old Kohn–Nirenberg quantization allows to construct a new class of LCQG (and also why the very good old Weyl quantization doesn't work here). This is a joint work (in progress) with Pierre Bieliavsky, Lars Tuset and Sergiy Neshveyev.

**Free afternoon**

**18:30 Conference dinner (Heurigen)**

• **Thursday, November 29, 2018**

**09:30 – 10:30**

**Speaker:** Sara Azzali

**Title:** Discrete group actions and a weak form of the Baum–Connes conjecture.

**Abstract:** Let  $\Gamma$  be a discrete group. We construct a Baum–Connes map localised at the unit element of  $\Gamma$ . This assembly map is formulated in KK-theory with coefficients in  $\mathbb{R}$ , and leads to a form of the Baum–Connes conjecture which is intermediate between the Baum–Connes conjecture and the strong Novikov conjecture. We explain these constructions and show the relation with the strong Novikov conjecture by characterising the so called  $\tau$ -part of the K-homology of  $\Gamma$  with real coefficients. In particular we compare, at the level of K-homology with real coefficients, the classifying space for free and proper actions  $E\Gamma$  with the classifying space for proper actions  $\underline{E}\Gamma$ . Joint work with Paolo Antonini and Georges Skandalis.

10:30 – 11:00 *Coffee / Tea Break*

**11:00 – 12:00**

**Speaker:** Pierre Julg

**Title:** K-theory of group  $C^*$ -algebras and the BGG complex

**Abstract:** The Baum–Connes conjecture on the K-theory of group  $C^*$ -algebras is a difficult open problem since the beginning of the 1980's. In the last 30 years a programme has been developed to prove the Baum–Connes conjecture with coefficients for semi-simple Lie groups. The tools involved are: the flag manifolds, the BGG complex, and L2 cohomology of symmetric spaces.

12:00 – 15:00 *Lunch Break*

15:00 – 15:30 *Coffee / Tea Break*

**15:30 – 16:30**

**Speaker:** Harold Steinacker

**Title:** From equivariant bundles to quantized space-times and higher-spin gauge theory

**Abstract:** We discuss recent work on certain quantized equivariant bundles over  $S^4$  and  $H^4$ . These non-commutative spaces are solutions of well-known matrix models, leading to higher-spin gauge theories with Euclidean and Minkowski signature.

• **Friday, November 30, 2018**

**09:30 – 10:30**

**Speaker:** Magnus Goffeng

**Title:** Constructing KMS-states from spectral triples.

**Abstract:** There are several facets of unbounded Kasparov theory and the associated noncommutative geo-

metries. The one we focus on in this talk is the associated measure theoretical objects. We construct KMS-states from spectral triples that are mildly better than  $\theta$ -summable. In examples such as Cuntz-Pimsner algebras, manifolds, and discrete groups we recover well known direct constructions from methods of unbounded KK. Joint work with Adam Rennie and Alexandr Usachev.

10:30 – 11:00 *Coffee / Tea Break*

**11:00 – 12:00**

**Speaker:** Franz Luef

**Title:** Function spaces in noncommutative geometry.

**Abstract:** Various problems in noncommutative geometry, such as the construction of vector bundles over noncommutative spaces, pseudodifferential operator calculi or index theory, involve analytic techniques which depend on function spaces well-adapted to the geometric properties of the space. I am going to present constructions of function spaces based on the features of the noncommutative space and as example I show that modulation spaces are a natural class of function spaces associated to the Moyal plane and noncommutative tori.

**Free afternoon**