Noncommutative Geometry and Mathematical Physics
Géométrie non commutative et physique mathématique
(Org: **Branimir Cacic** (UNB) and/et **Masoud Khalkhali** (UWO))

LATHAM BOYLE, Perimeter Institute
The Standard Model, Left-Right Symmetry and the Exceptional Jordan Algebra

Recently, an intriguing connection between the exceptional Jordan algebra $h_3(\mathbb{O})$ and the standard model of particle physics was noticed by Dubois-Violette and Todorov (with further interpretation by Baez). How do the standard model fermions fit into this story? I will explain how they may be neatly incorporated by complexifying $h_3(\mathbb{O})$ or, relatedly, by passing from $\mathbb{R}\otimes\mathbb{O}$ to $\mathbb{C}\otimes\mathbb{O}$ in the "magic square" of normed division algebras. This, in turn, suggests that the standard model, with gauge group $SU(3)\times SU(2)\times U(1)$, is embedded in a left/right-symmetric theory, with gauge group $SU(3)\times SU(2)\times SU(2)\times U(1)$. This theory is not only experimentally viable, but offers some explanatory advantages over the standard model (including an elegant solution to the standard model's "strong CP problem"). I will discuss the relationship to the idea that the standard model may be described by a spectral triple in noncommutative geometry.

MARCO DE CESARE, University of the Basque Country UPV/EHU
Noncommutative spacetime and bimetric gravity

I will present an extension of general relativity based on a twist-deformed spacetime and discuss its connections with bimetric gravity.

HEATH EMERSON, University of Victoria
Noncommutative geometry and Kronecker flow

We discuss a class of spectral triples over irrational rotation algebras going back to early work of Connes and more recent work of Lesch and Moscovici. We employ a slightly different construction and produce (new) examples of topologically nontrivial spectral triples over $C(\mathbb{T}^2)\rtimes\Lambda$ for Λ the (dense) subgroup of R generated by the integers and the slope θ of a Kronecker flow on $\mathbb{T}^2$. These triples have the meromorphic extension property if θ satisfies a Diophantine condition. We discuss applications to the KK-theory of A_θ and generalizations in progress to lattice pairs in $\mathbb{R}^n$.

SHANE FARNSWORTH, Max-Planck Institute for Gravitational Physics, Germany
'Jordan' nonassociative geometry and gauge theory

In this talk I will discuss the construction of gauge theories as 'Jordan' nonassociative geometries, and discuss the way in which these constructions relate to the analogous picture in noncommutative geometry.

REMUS FLORICEL, University of Regina
Inductive limits of spectral triples

We discuss several necessary and sufficient conditions for the existence of inductive limits of spectral triples, and illustrate these conditions with a few examples. This is based on joint work with A. Ghorbanpour.

HAMED HESSAM, Western University
Bootstrapping Random Noncommutative Geometries

In this talk we will see a technique called bootstraps can be applied to find the moments of a single matrix and two-matrix models taken from finite noncommutative geometries. We will discuss the relationships between the order parameter of the model and the second moment. From there all other moments are able to be expressed as in terms of the order parameter and the second moment, allowing them to be computed. This work is based on the joint paper of mine with Masoud Khalkhali and Nathan Pagliaroli.

MARCELO LACA, University of Victoria
Low-temperature spectroscopy for number fields

We establish, in the context of general C*-dynamical systems, a precise way to associate partition functions to extremal KMS states that are of type I. The study is motivated by low-temperature phase transitions exhibited by certain C*-dynamical systems that arise from number fields, which do not have intrinsic Hamiltonians because their observed absorption spectra varies depending on the equilibrium configuration. However, the resulting collection of partition functions can be used as an invariant for number fields and congruence monoids. This is joint work with Chris Bruce and Takuya Takeishi.

THERESE-MARIE LANDRY, University of California, Riverside
Metric Convergence of Spectral Triples on the Sierpinski Gasket and other Fractal Curves

Many important physical processes can be described by differential equations. The solutions of such equations are often formulated in terms of operators on smooth manifolds. A natural question is to determine whether differential structures defined on fractals can be realized as a metric limit of differential structures on their approximating finite graphs. One of the fundamental tools of noncommutative geometry is Connes' spectral triple. Because spectral triples generalize differential structure, they open up promising avenues for extending analytic methods from mathematical physics to fractal spaces. The Gromov-Hausdorff distance is an important tool of Riemannian geometry, and building on the earlier work of Rieffel, Latremoliere introduced a generalization of the Gromov-Hausdorff distance that was recently extended to spectral triples. The Sierpinski gasket can be viewed as a piecewise C^1-fractal curve, which is a class of fractals first formulated by Lapidus and Sarhad for their work on spectral triples that recover the geodesic distance on these spaces. In this talk, we will motivate and describe how their framework was adapted to our setting to yield approximation sequences suitable for metric approximation of spectral triples on piecewise C^1-fractal curves.

NATHAN PAGLIAROLI, Western University
Phase Transition in Random Noncommutative Geometries

Finite spectral triples where the algebra is the space of N by N Hermitian matrices are an example of a matrix geometry. Such spaces can be equipped with a probability measure on the moduli space of its Dirac operator creating ensembles of Dirac operators. Numerical evidence has shown that these ensembles exhibit evidence of phase transition as well as the spectrum being related to that of the fuzzy 2-sphere. In this talk we will discuss a proof of the existence of phase transitions in certain Dirac ensembles as well as how to compute their spectral density function. This work is based on the joint paper of mine with Masoud Khakhali arXiv:2006.02891.

RAPHAEL PONGE, Sichuan University
Dixmier trace formulas and negative eigenvalues of Schrödinger operators on noncommutative tori.

This talk has two main results. The first result is an extension of Connes' integration formula to noncommutative tori equipped with general Riemannian metrics. The second main result is a version for noncommutative tori of the Cwikel-Lieb-Rozenblum inequality for negative eigenvalues of Schrödinger operators on noncommutative tori. This leads to conjecture a semiclassical Weyl's law for noncommutative tori. This shows that we can do Riemannian geometry in a quantum setting. Both results are consequences of a new version of Cwikel estimates for weak Schatten classes. This is joint work with Edward McDonald (UNSW-Sydney, Australia).

ILYA SHAPIRO, University of Windsor
Relative Hopf-cyclic cohomology

Motivated by the need to extend the definition of anti-Yetter-Drinfeld modules for Hopf algebras in symmetric categories to the more general braided categories we realize that the question is ill-posed. What one has instead is a localization of the usual coefficients.

ANDRZEJ SITARZ, Jagiellonian University
Models of products of noncommutative geometries.

Models of noncommutative geometry that are products of manifolds with discrete spaces, which have Dirac operators that are not of product type, lead to interesting physical theories in the gravity and particle sectors. The gravity construction appears to be similar to the bimetric gravity modifications whereas the nonproduct structure applied to the description of the Standard Model leads to no fermion doubling with explicit CP breaking and additional topological terms.

KAREN STRUNG, Institute of Mathematics, Czech Academy of Sciences
Positive line bundles over the irreducible quantum flag manifolds

Noncommutative Kähler structures were recently introduced by Ó Buachalla as a framework for studying noncommutative Kähler geometry on quantum homogeneous spaces. The notion of a positive vector bundle directly generalises to this setting. For covariant Kähler structures of irreducible type (those having an irreducible space of holomorphic 1-forms) we provide simple cohomological criteria for positivity, offering a means to avoid explicit curvature calculations. These general results are applied to our motivating family of examples, the irreducible quantum flag manifolds $O_q(G/L_S)$. Building on the recently established noncommutative Borel-Weil theorem, every covariant line bundle over $O_q(G/L_S)$ can be identified as positive, negative, or flat, and hence we can conclude that each Kähler structure is of Fano type. This is joint work with Díaz García, Ó Buachalla, Krutov, and Somberg.

LUUK VERHOEVEN, University of Western Ontario
Embedding spheres into Euclidean space using unbounded Kasparov products

We construct an unbounded representative for the shriek class associated to the embeddings of spheres into Euclidean space. We equip this unbounded KK-cycle with a connection and compute the unbounded Kasparov product with the Dirac operator on $\mathbb{R}^{n+1}$. We find that the resulting spectral triple for the algebra $C(S^n)$ differs from the Dirac operator on the round sphere by a so-called index cycle, whose class in $KK_0(\mathbb{C};\mathbb{C})$ represents the multiplicative unit. At all points we check that our construction involving the unbounded Kasparov product is compatible with the bounded Kasparov product using Kucerovsky's criterion and we thus capture the composition law for the shriek map for these immersions at the unbounded KK-theoretical level, while retaining the geometric information. The end goal of this project will be to generalize this construction to arbitrary immersions of manifolds.