GAPT Seminars 2016-17

Date	Speaker	Seminar
6 October 2016	Thomas Prince (Imperial)	**Mutations of polytopes** Mutations of polytopes first appeared in work of Akhtar-Coates-Galkin-Kasprzyk as a combinatorial description of a certain class of birational maps acting on Laurent polynomials. We provide a concrete connection from this theory (in 2 dimensions) to that of quiver mutation and of cluster algebras, and use this to produce a finite type classification for Fano polygons. We give another interpretation of a mutation (in any dimension), as a 'perturbation of the affine structure' of a polytope. Using this we recover a result of Ilten that polytopes related by mutation appear as special fibers of a flat family over $\mathbf{P}^1$and extend this result to 'simultaneously' produce deformations for certain collections of mutations.
13 October 2016	Ulrich Pennig (Cardiff)	**Connective C*-algebras** Topological K-theory and K-homology can be generalised to bivariant E-theory of C^*-algebras. The group $E(A,B)$ is defined in terms of asymptotic morphisms between stabilised suspensions of both algebras. Since unsuspended asymptotic morphisms contain a priori more geometric information, the question arises, when we can avoid suspension. In joint work with Marius Dadarlat, we studied a homotopy invariant property called connectivity, which gives a complete answer in the nuclear case. It has a lot of other interesting implications like absence of nonzero projections and quasidiagonality and it has good permanence properties. In the talk I will give a short introduction to E-theory and explain connectivity. I will then discuss examples and counterexamples of connective C^*-algebras.
20 October 2016	Alexander Schenkel (Nottingham)	**Towards homotopical algebraic quantum field theory** An algebraic quantum field theory is an assignment of algebras to spacetimes. These algebras should be interpreted as quantizations of the algebras of functions on the moduli spaces of a classical field theory. In many cases of interest, especially in gauge theories, these moduli spaces are not conventional spaces but `higher spaces' called stacks. Consequently, functions on such spaces do not form an algebra but a `higher algebra' which one may describe by homotopical algebra. This motivates us to study assignments of `higher algebras' to spacetimes, which is what I call homotopical algebraic quantum field theory. In this talk I will clarify the above picture and explain its advantages compared to traditional algebraic quantum field theory. For this I will also present simple toy-models related to Abelian gauge theory and homotopy Kan extensions.

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27 October 2016	Andreas Aaserud (Cardiff)	**Approximate equivalence of measure-preserving actions** I will talk about measure-preserving actions of countable discrete groups on probability spaces. Classically, one mainly considered two notions of equivalence of such actions, namely conjugacy (or isomorphism) and orbit equivalence, both of which have nice descriptions in the language of von Neumann algebras. I will briefly discuss this classical framework before going into some new notions of equivalence of actions. These are approximate versions of conjugacy and orbit equivalence that were introduced and investigated by Sorin Popa and myself last year, and which can be most easily defined in terms of ultrapowers of von Neumann algebras. I will discuss superrigidity within this new framework, and will also compare approximate conjugacy to (classical) conjugacy for actions of various classes of groups. This talk is based on joint work with Sorin Popa.
3 November 2016	Paul Fendley (Oxford)	**Integrable Statistical Mechanics in Mathematics** I will survey some of the many significant connections between integrable many-body physics and mathematics. I exploit an algebraic structure called a fusion category, familiar from the study of conformal field theory, topological quantum field theory and knot invariants. Rewriting statistical-mechanical models in terms of a fusion category allows the derivation of combinatorial identities for the Tutte polynomial, the analysis of discrete "holomorphic" observables in probability, and to defining topological defects in lattice models. I will give a little more detail on topological defects, explaining how they allow exact computations of conformal-field-theory quantities directly on the lattice, as well as a greatly generalised set of duality transformations.
10 November 2016	Sarah Whitehouse (Sheffield)	**Associativity from a topologist's point of view** Many familiar algebraic operations are associative. To a topologist, it is more natural to consider operations which are "associative up to homotopy" and I will discuss what this means. As soon as one does this, one is led to a rich structure with an infinite family of operations, known as an A-infinity structure. These structures have become important in many different areas of mathematics, including algebra, geometry and mathematical physics. One can play similar topological games with other algebraic conditions. I will survey some of this 50 year old story and discuss some recent developments.
17 November 2016	Jeffrey Giansiracusa (Swansea)	**Tropical geometry, matroids and the commutative algebra of idempotent semirings** Tropical geometry is a tool that can reduce problems in algebraic geometry to piecewise polyhedral geometry and combinatorics, but it is

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		also a new world of geometry in its own right. In this talk I will introduce the emerging picture of this kind of geometry as parallel to Grothendieck's vision of algebraic geometry. Here rings are replaced by idempotent semirings, and role of linear algebra in classical commutative algebra is replaced by the combinatorics of matroids.
24 November 2016	Jelena Grbic (Southampton)	**Homotopy theory of toric objects** At the beginning of this millennium, Toric Topology has been recognised as a new branch of Topology closely related to Algebraic Geometry, Combinatorics and Algebra. Initially problems of Toric Topology were motivated by the study of toric geometry. The approach I take departs from geometry and brings in the tools and techniques of homotopy theory. That allows one to generalise the fundamental concepts of Toric Topology to new once which will further have applications to geometric group theory, robotics and applied mathematics.
1 December 2016	Christopher Parker (Birmingham)	**Understanding finite simple groups** In this talk I will describe a project which aims to understand large families of the finite simple groups by determining the structure of normalizers of non-trivial *p*-subgroups of *G* for a fixed prime *p*. I will discuss some of the problems that arise in this new approach and also feature some of the new results which will be used. The main new results are joint work with Pientka, Seidel and Stroth.
8 December 2016	Selcuk Barlak (Odense)	**Classification of simple, nuclear C*-algebras and the universal coefficient theorem** A C*-algebra is a closed *-subalgebra of the algebra of bounded linear operators on some Hilbert space. Originally considered for the purpose of a mathematical description of quantum mechanics, C*-algebras in their own right have been studied extensively, especially since their abstract characterisation by Gelfand and Naimark in 1943. Nuclear C*-algebras form a prominent subclass, characterised in terms of a certain finite dimensional approximation property. Very recently, by work of many hands over several years, a big class of separable, simple, nuclear C*-algebras satisfying further technical regularity properties has been classified successfully in terms of K-theoretical data. In this talk, I will outline these results and point out the probably most mysterious of these regularity properties: the universal coefficient theorem (UCT) by Rosenberg and Schochet. I will then present recent joint work with Xin Li on the question which nuclear C*-algebras satisfy the UCT.

Date	Speaker	Seminar
5 January 2017 **14.00-15.00**	Christopher Marks (CSU Chico)	**Modularity of minimal model 1-point functions** It is by now a “classical” fact that 1-point functions arising from rational vertex operator algebras (VOAs) are modular forms, but more recent work of Miyamoto and others proves that this modularity property continues to hold in the more general setting of intertwining operators for rational VOAs. We will discuss some recent work (joint with Matt Krauel) that explores which modular forms arise as 1-point functions associated to intertwining operators for Virasoro minimal models, and in particular we will discuss how one may produce many examples of noncongruence modular forms in this setting.
5 January 2017 **15.30-16.30**	Matthew Krauel (CSU Sacramento)	**Recursive formulas in the theory of vertex operator algebras and their uses** In this talk I will introduce the notion of *n*-point functions in the theory of vertex operator algebras (VOAs) and provide formulas which allow *n*-point functions to be written as linear combinations of (*n*-1)-point functions. This discussion will include results of Zhu's, along with more recent progress. We will also discuss some uses of these formulas for studying *n*-point functions of VOAs.
19 January 2017	Yasuyuki Kawahigashi (Tokyo)	**Relative tensor products of full conformal field theories** I will describe new aspects of the operator algebraic description of 2-dimensional conformal field theory. We have an operator algebraic formulation of chiral conformal field theory, and then describe how to build a full conformal field theory from two chiral conformal field theories in the language of modular tensor categories. Modular invariance naturally appears here and this leads us to consider a new type of relative tensor products. I will not assume any knowledge on conformal field theory or operator algebras.
2 February 2017	Noah Snyder (Indiana)	**Subfactors and their classification** Subfactors are inclusions of von Neumann factors, and play a similar role in operator algebras that Galois theory plays in ring theory. Each subfactor has an index, analogous to the degree of a field extension, but these indices do not need to be integers. The celebrated Jones index theorem says that among subfactors of index up to 4, only a discrete sequence of index values can happen. This suggests that there may be some hope of classifying subfactors. Such a classification splits into two steps, one largely algebraic and the other largely analytic. The algebraic step is to classify certain "quantum group"-like objects that play the role of Galois groups. The analytic step

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		is to then understand how many ways each of these "quantum groups" can act on a particular factor. I'll mainly focus on the algebraic part of the classification, which is now known up to index 5.25, and the examples that appear in this classification. I'll also briefly discuss what's known about the analytic part of the classification in the case of the hyperfinite II_1 factor, based on deep results of Ocneanu and Popa.
9 February 2017	Michal Wrochna (Grenoble)	**Quantum fields on asymptotically de Sitter spacetimes and their extension across the conformal horizon** In QFT on curved spacetimes, a key problem is the construction of physical states. These are characterized by the so-called Hadamard condition, formulated in the language of microlocal analysis, and a further desirable property are (asymptotic) symmetries. In this talk, I will present a solution to this problem on asymptotically de Sitter spacetimes, derived in a recent joint work with András Vasy. The crucial feature is the extendability of appropriately rescaled classical fields across the conformal horizon, to a region consisting of two asymptotically hyperbolic spaces. It turns out that quantum fields follow the same behaviour and are uniquely determined by data in the asymptotically hyperbolic spaces.
16 February 2017	André Henriques (Oxford)	**Representations of the based loop group** The free loop group of a compact Lie group has a very interesting representation theory, related to modular forms, integrable systems, quantum groups, vertex algebras, string theory... Of particular interest is the fusion product of representations. The representation theory of the *based* loop groups have never been considered before (even though individual examples of representations have been considered in disguise). We will explain how to extend the fusion product to representations of the based loop groups, and how to recover the category of representations of the free loop group from the category of representations of the based loop group. At last, I will explain in what sense I expect the representation theory of based loop groups to be wild (unlike that of the based loop groups), and which representations one might have a hope to classify.
23-24 February 2017		**2CinC: Cow and Calf in Cardiff** Speakers: Hamid Ahmadinezhad (Loughborough), Francesca Balestrieri (Oxford), Anna Barbieri (Sheffield), Sjoerd Beentjes (Edinburgh), Alastair Craw (Bath), Domenico Fiorenza (Rome), Elana Kalashnikov (Imperial), Roberto Laface (Hannover), Sara Muhvić (Warwick), Elisa Postinghel (Loughborough), Rory Potter (Sheffield), Jason Van Zelm (Liverpool)

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2 March 2017	Simon Wood (Cardiff)	**Conformal field theory, vertex operator algebras and symmetric functions: How do they all fit together? Part 1** I will give brief rundown of what conformal field theories are and how they bring forth vertex operator algebras. I will then discuss some issues researchers commonly face when trying to understand the representation theory of vertex operator algebras. If time permits, I will also discuss how symmetric functions can come to the rescue (or at least how they have done so in my own research).
9 March 2017	Simon Wood (Cardiff)	**Conformal field theory, vertex operator algebras and symmetric functions: How do they all fit together? Part 2** This will be a continuation of the talk from last week, discussing symmetric functions and their appearance in my own research.
16 March 2017	Jørgen Rennemo (Oxford)	**The Torelli theorem for cubic 4-folds via derived categories** Let X be a compact complex curve. The complex structure on X gives a direct sum decomposition of the cohomology group $H^1(X,C)$ into holomorphic and anti-holomorphic 1-forms, and the classical Torelli theorem says that this splitting uniquely determines X as a complex curve. Similar results hold for certain classes of varieties in higher dimensions. In these cases the splitting of $H^1(X,C)$ is generalised to the more refined data of a Hodge decomposition of some cohomology group, and one typically proves a statement saying that the Hodge decomposition determines the complex structure of a variety. K3 surfaces and cubic 4-folds are two classes of varieties for which such a "generalised Torelli theorem" is known. In this talk I'll explain some ingredients in a new proof of the Torelli theorem for cubic 4-folds, which uses a recently discovered connection between the derived categories of coherent sheaves of cubic 4-folds and K3 surfaces. This is based on joint work with Daniel Huybrechts.
23 March 2017	David McConnell (Cardiff)	**Bundles of C*-algebras** The Gelfand Naimark Theorem tells us that a commutative C^*-algebra is naturally isomorphic to the C^*-algebra $C_0(X)$ of continuous, complex valued functions vanishing at infinity on a locally compact Hausdorff space X. In the non-commutative setting, the following question therefore arises quite naturally: given a C^*-algebra A, can we find a base space X and a bundle of C^*-algebras over X, such that A is naturally isomorphic to the algebra of all continuous sections (vanishing at infinity) of this bundle?

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		While the answer is always yes, the bundle that is obtained can be quite pathological (and not always helpful). Nonetheless, there is a large class of *C**-algebras that admit nice representations as section algebras of bundles, the study of which has made significant contributions to our understanding of non-commutative *C**-algebras. In this talk I will discuss the various ways of constructing *C**-bundles from *C**-algebras, and some of my own work in this area.
6 April 2017	Andreas Recknagel (King's)	**Orbifold equivalence in topological Landau-Ginzburg models** Matrix factorisations provide a description of supersymmetric boundary conditions in topological LG models, and of defects between two such LG models. An orbifold equivalence is a defect having specific additional properties (which allow to use it in generalised orbifold procedures and to establish equivalences between categories associated to the LG potentials). The talk addresses the problem of constructing concrete orbifold equivalences.
16 May 2017 **17:00-18:00** Council Chamber (Main Building)	Stefaan Vaes (K.U. Leuven)	**LSW Frontiers Lecture** **The Banach-Tarski paradox and von Neumann's concept of amenability** Banach and Tarski proved in 1924 that it is possible to cut a ball into five pieces and to reassemble these pieces by rotation and translation into two balls of the same radius. At the same time, there is no such paradoxical decomposition of the two dimensional disc. I will sketch a proof of this result using key ideas of von Neumann about the qualitatively very different behavior of the symmetries of the two-dimensional plane compared to the symmetries of the three-dimensional space. I will also present more recent striking applications of these ideas throughout mathematics. **https://www.learnedsociety.wales/lsw-event/banach-tarski-paradox-von-neumanns-concept-amenability/**