LMS SW&SW Regional Meeting and Workshop on Algebraic Structures and Quantum Physics

Cardiff, 13-15 December 2017

Programme

Wednesday, 13 December 2017 – LMS Graduate Student Meeting

9:30-10:00	Hassan Izanloo (Cardiff)	E2.20
10:00-10:30	Rudradip Biswas (Manchester)	E2.20
10:30-11:00	*Coffee break*	*M1.02*
11:00-11:30	Munerah Almulhem (Swansea)	E2.20
11:30-12:30	Edwin Beggs (Swansea): Introductory lecture 1	E2.20
12:30-13:30	*Lunch*	*M1.02*
13:30-14:30	Ulrich Pennig (Cardiff): Introductory lecture 2	E2.20

Wednesday, 13 December 2017 – LMS South Wales & South West Regional Meeting

14:30-15:00	*Tea/coffee on arrival*	*M0.37*
15:00-15:15	Opening of the LMS meeting	M0.40
15:15-16:15	Shahn Majid (QMUL)	M0.40
16:15-17:00	*Coffee break*	*M0.37*
17:00-18:00	Ingo Runkel (Hamburg)	M0.40
18:30	*Reception*	*Jurys Inn – Duchess Suite*
19:30	*Dinner*	*Jurys Inn – Duchess Suite*

Thursday, 14 December 2017 – Workshop on Algebraic Structures and Quantum Physics

10:00-11:00	Christian Korff (Glasgow)	M2.06
11:00-11:30	*Coffee break*	*M1.02*
11:30-12:30	Michael Tuite (Galway)	M2.06
12:30-13:30	*Lunch*	*M1.04*
13:30-14:30	Chris Fewster (York)	E2.20
14:30-15:00	*Coffee break*	*M1.02*
15:00-16:00	Veronique Fischer (Bath)	E2.20
16:00-16:30	*Coffee break*	*M1.02*
16:30-17:30	Ben Musto (Oxford)	M2.06
17:30-18:00	Christos Aravanis (Sheffield)	M2.06

Friday, 15 December 2017 – Workshop on Algebraic Structures and Quantum Physics

9:30-10:30	Ko Sanders (Dublin)	E2.20
10:30-11:00	*Coffee break*	*M1.02*
11:00-12:00	Pieter Naaijkens (Aachen)	E2.20
12:00-13:30	*Lunch*	*Aberdare Hall*
13:30-14:30	Ulrich Pennig (Cardiff)	E2.20
14:30-15:00	*Coffee break*	*M1.02*
15:00-16:00	Anne Taormina (Durham)	E2.20

LMS SW&SW Regional Meeting and Workshop on Algebraic Structures and Quantum Physics
Cardiff, 13-15 December 2017

Regional Meeting Titles and Abstracts

Shahn Majid (QMUL): Braided algebra and dual bases of quantum groups

It is well-known that quantum groups can be used to generate braided categories and hence invariants of knots and braids. In this talk I will focus on the opposite, i.e. doing braided algebra and braided-Hopf algebra at the level of braid diagrams as a way to construct new quantum groups and gain insight into their deeper structure. It is known that every braided category has at its heart one of these braided-Hopf algebras. Moreover, every rigid braided-Hopf algebra in the category of representations of a quantum group leads to a new braided category and a new quantum group (called the `double-bosonization' of the braided-Hopf algebra) of which this is the category of representations.

I will illustrate how this inductively constructs q-deformed quantum groups u_q(g) of semisimple Lie algebras at certain special roots of unity in a way that automatically provides the dual basis to their PBW basis. This also provides new formulae for their quantum double R-matrix needed for applications of in quantum gravity and quantum computing, as well as a way to construct new and exotic quantum groups.

Ingo Runkel (Hamburg): Categorification and field theory

The exchange of ideas between mathematics and physics has been an important source of progress. Group theory and symmetries in physical models provide an important example of this. A more recent mathematical tool, category theory, has also started to make its way into the description of physical theories. In this talk I would like to speak about topological quantum field theory, and how it links two ideas: On the mathematical side, there is categorification, a fancy way of saying that when one sees a non-negative integer one should try to think of it as the dimension of some vector space. On the physical side, there is the idea to study simplified models in fewer dimensions first and then try to pass to higher dimensions.

LMS SW&SW Regional Meeting and Workshop on Algebraic Structures and Quantum Physics
Cardiff, 13-15 December 2017

Workshop on Algebraic Structures and Quantum Physics Titles and Abstracts

Chris Fewster (York): An analogue of the Coleman-Mandula theorem for QFT in curved spacetimes
The Coleman-Mandula (CM) theorem states that the Poincaré and internal symmetries of a Minkowski spacetime quantum field theory cannot combine nontrivially in an extended symmetry group. In this talk I will describe some of the background to the CM theorem and then establish an analogous result for a general class of quantum field theories in curved spacetimes. Unlike the CM theorem, our result is valid in dimensions n≥2 and for free or interacting theories. It makes use of a general analysis of symmetries induced by the action of a group *G* on the category of spacetimes. Such symmetries are shown to be canonically associated with a cohomology class in the second degree nonabelian cohomology of *G* with coefficients in the global gauge group of the theory. The main result proves that the cohomology class is trivial if *G* is the universal cover *S* of the restricted Lorentz group. Among other consequences, it follows that the extended symmetry group is a direct product of the global gauge group and *S*, all fields transform in multiplets of *S*, fields of different spin do not mix under the extended group, and the occurrence of noninteger spin is controlled by the centre of the global gauge group.

Veronique Fischer (Bath): Pseudo-differential operators on Lie groups
This talk will start with a personal and partial overview of harmonic analysis and its relations with quantum mechanics, especially via micro-local and semi-classical analysis (pseudo-differential theory). We will then discuss recent developments in the pseudo-differential theory on Lie groups.

Christian Korff (Glasgow): The Verlinde Algebra and quantum Bäcklund transformations
Starting from the canonical quantisation of the Ablowitz-Ladik chain we discuss the quantum analogue of a Baecklund transformation which defines a discrete time evolution for the resulting quantum system of *q*-bosons, where *q* is the quantisation parameter. We show that the composition of multiple Baecklund transformation defines a 2D TQFT which at $q=0$ describes the $su(n)$ WZW Fusion Ring. At $q=1$ one obtains free bosons but the underlying combinatorics of the TQFT fusion coefficients is still interesting: they are related to cylindric reverse plane partitions and the generalised symmetric group.

Pieter Naaijkens (Aachen): Stability of superselection sectors of topologically ordered models
Topologically ordered quantum spin models, such as Kitaev's toric code, have many interesting properties. One of them is that they have anyonic excitations, i.e. excitations which have braided statistics. These excitations and their properties can be studied in the spirit of the Doplicher-Haag-Roberts programme in algebraic quantum field theory, to recover the full modular tensor category describing them. This analysis is done with respect to a reference representation, typically coming from a translation invariant ground state of the system, which plays the role of the vacuum. An important question is if this structure is stable. That is, if we perturb the dynamics, and obtain a new ground state, do we get the same modular tensor category? In my talk I will discuss recent results in this direction. Joint work with Matthew Cha and Bruno Nachtergaele.

Ulrich Pennig (Cardiff): Yang-Baxter representations of the infinite symmetric group
The Yang-Baxter equation was introduced as a consistency equation in statistical mechanics, but has since then appeared in many other research areas, for example integrable quantum field theory, knot theory, the study of Hopf algebras and quantum information theory. Its solutions are called *R*-matrices. In this talk I will discuss a joint project with G. Lechner and S. Wood, in which we found a complete classification of all unitary involutive *R*-matrices up to a natural equivalence relation. Each such *R*-matrix defines a representation and an extremal character of the infinite symmetric group and we identify the ones that come from R-matrices among all such characters using techniques involving operator algebras.

Ko Sanders (Dublin): Modular nuclearity and entanglement entropy in algebraic QFT
Entanglement is an important experimental resource in quantum physics, and entanglement entropy is a measure for the amount of entanglement (which may be infinite). In the context of algebraic quantum field theory (AQFT) I will describe how the entanglement entropy can be estimated in terms of nuclearity properties of suitable modular operators. Such nuclearity properties have been established in several toy model cases and there are reasons to believe that they hold quite generally. This talk is based on joint works with G. Lechner, with S. Hollands and with O. Islam.

Anne Taormina (Durham): The stringy origin of Mathieu Moonshine
I will review how Mathieu Moonshine emerges from considering the dynamics of strings with extended supersymmetry.

Michael Tuite (Galway): Zhu reduction for vertex operator algebras on Riemann surfaces
A Vertex Operator Algebra (VOA) is an algebraic formulation of a chiral conformal field theory. One of the most important tools in VOA theory is Zhu reduction which allows one to expand genus one correlation functions in terms of elliptic functions. In this talk I will discuss recent progress in extending Zhu reduction to Riemann surfaces of genus two and beyond. In particular, Zhu reduction is explicitly expressed in terms of certain Green's functions and holomorphic differentials. I also discuss some applications such as an $Sp(4,\mathbf{Z})$ invariant differential equation describing the genus two partition functions for the (2,5) minimal model generalizing the Rogers-Ramanujan functions to genus two.

LMS SW&SW Regional Meeting and Workshop on Algebraic Structures and Quantum Physics
Cardiff, 13-15 December 2017

Graduate Student Titles and Abstracts

Munerah Almulhem (Swansea): Skew derivations on generalized Weyl algebras
This talk is based on a joint work with T. Brzezinski. In this talk, a wide class of skew derivations on degree-one generalized Weyl algebras $R(a,\Phi)$ over a ring R is constructed. All these derivations are twisted by a degree-counting extensions of automorphisms of R. It is determined which of the constructed derivations are Q-skew derivations. The compatibility of these skew derivations with the natural $\mathbf{Z}$-grading of $R(a,\Phi)$ is studied. In addition local nilpotency of constructed derivations is studied. General constructions are illustrated by description of all skew derivations (twisted by a degree-counting extension of the identity automorphism) of generalized Weyl algebras over the polynomial ring in one variable and with a linear polynomial as the central element.

Christos Aravanis (Sheffield): Derived categories and Rozansky-Witten theory
In 1996 Rozansky and Witten introduced a three-dimensional topological sigma model, whose target space is a hyperkahler manifold. The perturbative expansion of the sigma model's partition function gives rise to a system of weights associated to trivalent graphs, also known as Rozansky-Witten weight systems. Roberts and Willerton studied these weight systems using the derived category of coherent sheaves. In this talk, after introducing basic facts about Rozansky-Witten theory and derived categories, we will discuss how we can use the derived category of coherent sheaves to construct an extended TQFT for the Rozansky-Witten theory. This is work in progress for my PhD under Simon Willerton at the University of Sheffield.

Rudradip Biswas (Manchester): Settling the differences between different class systems of groups
I will, in the beginning, give a brief outline of Kropholler's hierarchical classification of groups and then relate it to another classification as proposed by Ikenaga. I will provide some methods of distinguishing these classes by examples of groups that might belong to one class in one of these classifications and not in the other. I hope to illustrate how the openness of certain conjectured relations involving these classes affect our understanding of them.

Hassan Izanloo (Cardiff): Alternating sign matrix partially ordered set point of view
An alternating sign matrix of order n, or ASM for short, is an n by n matrix with entries -1, 0 or 1 for which all its row/column sums equal to 1 and non-zero entries in each row and column alternate in sign. In this talk we first construct a partially ordered set, or poset for short, within the set of all ASMs of order n and then investigate its properties and applications.

Ben Musto (Oxford): Graphical finite fields in Hilbert space
We introduce a new tensor diagrammatic characterisation of finite fields as algebraic structures defined over Hilbert spaces using category theory. We also introduce a diagrammatic characterisation of maximal families of mutually unbiased bases. We give a new construction of maximal families of mutually unbiased bases, from a finite field using this formalism, which is simpler and more direct than previous proposals.