TITLES AND ABSTRACTS

Stephen Bartlett

Title. Topological phases in quantum information

Abstract. Topological phases have found a natural application in the long-time storage of quantum bits, which will be a key requirement in the development of quantum computing. I will discuss topological phases of spin lattice systems from the perspective of robust quantum memories. I'll also present some recent results on how symmetries can provide thermal stability of topological order in such systems, providing an avenue for quantum memories that are stable at non-zero temperature.

Ugo Bruzzo

Title. Higgs bundles and fundamental group schemes

Abstract. Relying on a notion of *numerical effectiveness* for Higgs bundles, we show that the category of *numerically flat* Higgs vector bundles on a smooth projective variety X is a Tannakian category. We introduce the associated group scheme, that we call the *Higgs fundamental group scheme of* X, and show that its properties are related to a conjecture about the vanishing of the Chern classes of numerically flat Higgs vector bundles. (Joint with I. Biswas and S. Gurjar)

Krzysztof Gawedzki

Title. Gerbes and time-reversal-invariant topological insulators

Abstract. I shall discuss equivariant bundle gerbes on the unitary group and their application to the construction of indices classifying time-reversal symmetric topological insulators, both static and periodically driven.

Gian Michele Graf

Title. Bulk-edge correspondence in the presence of a mobility gap

Abstract. Band insulators are characterized by the Fermi energy lying in a spectral gap. More generally, we consider situations where that energy lies within the spectrum, though in an regime of localization. We discuss how indices are defined and affected by that situation, as well as the relation between edge and bulk. The discussion is pedestrian and is based on examples in dimension 1 and 2 exhibiting different symmetries.

Pinhas Grossman

Title. Subfactors and Modular Tensor Categories

Abstract. Modular tensor categories (MTCs) appear as algebraic structures in conformal field theory and have been used to study quantum computation. One major source of examples of MTCs is representation theory of groups and quantum groups. In recent years new examples of MTCs have been discovered through the study of subfactors, which are inclusions of operator algebras.

In this talk we will explain the relationship between subfactors and MTC's, and then discuss some examples.

Hao Guo

Title. Spin^c, K-homology and proper actions

Abstract. In this talk, I will summarise several new results, joint with Mathai Varghese and Hang Wang, in G-equivariant K-homology and G-equivariant index theory, where G is an almost connected Lie group. In addition to sketching the main results, I will show how one can use the results to obtain a generalisation of Hattori's Vanishing theorem. This work arose from the topic of the speaker's Ph.D. thesis.

Keith Hannabuss

Title. T-duality and the condensed matter bulk-boundary correspondence

Abstract. This talk will start with a brief historical review of the classification of solids by their symmetries, and the more recent K-theoretic periodic table of Kitaev. It will then consider some mathematical questions this raises, in particular about the behaviour of electrons on the boundary of materials and in the bulk. Two rather different models will be described, which turn out to be related by T-duality. Relevant ideas from noncommutative geometry will be explained where needed.

Motoko Kotani

Title. Topology in Materials

Abstract. Materials is a complex hierarchical system with multiple sizes. To understand relations between structures and properties/functions, we need abstract essential geometric structures from the complex systems. In the present talk, I would like to discuss topology in materials such as metallic glasses, carbon networks, highly concentrated particle systems.

Yosuke Kubota

Title. Classification of topological phases via coarse topology

Abstract. In condensed matter physics, it is known that some topological properties of quantum systems are related to the topology of the Hamiltonian operator as a self-adjoint operator with a spectral gap. In particular, recent researches reveal that symmetries of quantum systems, such as time-reversal or particle-hole symmetries, provide a rich physical and mathematical theory. In this talk, we introduce relations between classification of non translation-invariant topological phases and the operator algebras in coarse topology. Classification of topological phases, a primary invariant called 'index' and the bulk-edge correspondence for these invariants are described in terms of twisted equivariant K-theory of coarse C*-algebras. It contains a new result on the bulk-edge correspondence for quasicrystals.

Tianshu Liu

Title. Towards the N=2 minimal models

Abstract. Conformal field theory is an essential tool of modern mathematical physics with applications to string theory and to the critical behaviour of statistical lattice models. The symmetries of a conformal field theory include all angle-preserving transformations. In two dimensions, these transformations generate the Virasoro algebra, a powerful symmetry that allows one to calculate observable quantities analytically. The symmetries of a conformal field theory may be strictly larger than the Virasoro algebra. One possibility which is crucial importance to string theory applications is that of supersymmetry, where the Virasoro algebra is extended by a given number of fermionic fields. The talk aims to explain certain aspects of N=2 superconformal field theory using the arsenal of mathematical technology and physical insight that has been built up over the last five years.

Giuseppe de Nittis

Title. Topological nature of the Fu-Kane-Mele invariants

Abstract. Condensed matter electronic systems endowed with an odd time-reversal symmetry (TRS) (a.k.a. class AII topological insulators) show topologically protected phases which are described by an invariant known as Fu-Kane-Mele index. The construction of this invariant, in its original form, is specific for electrons in a periodic background and is not immediately generalizable to other interesting physical models where different forms of TRS also play a role. By exploiting the fact that system with an odd TRS (in absence of disorder) can be classified by Quaternionic vector bundles, we introduce a Quaternionic topological invariant, called FKMM-invariant, which generalizes and explains the topological nature of the Fu-Kane-Mele index. We show that the FKMM-invariant is a universal characteristic class which can be defined for Quaternionic vector bundles in full generality, independently of the particular nature of the base space. Moreover, it suffices to discriminate among different topological phases of system with an odd TRS in low dimension. As a particular application we describe the complete classification over a big class of low dimensional involutive spheres and tori. We also compare our classification with recent results concerning the description

of topological phases for two-dimensional adiabatically perturbed systems.

Emil Prodan

Title. A Computational Non-Commutative Geometry Program for Topological Insulators

Abstract. I will review the foundations of a computational non-commutative geometry program for strongly disordered topological insulators. Using mostly algebraic techniques, I will present error estimates for optimal finite-volume approximations of the topological invariants, showing that they converge exponentially fast to the thermodynamic limit. The performance of the algorithms will be exemplified for both bulk and boundary invariants. If time permitting, I will draw the general lines of a much broader computational program which we are currently exploring.

Thomas Quella

Title. Symmetry protected topological phases in one dimension: Beyond groups

Abstract. We show that phases of 1D quantum systems may enjoy symmetry protection even in the absence of standard symmetries. This observation leads to a broader definition of symmetry protected topological phases than currently used in the literature.

David Ridout

Title. Symmetric functions and minimal model vertex operator algebras.

Abstract. An old observation of Wakimoto and Yamada links the theory of Jack symmetric functions with the singular vectors of Virasoro Verma modules. This link lay semi-dormant for many years until it was revived in the N=1 setting relating to the AGT conjectures. Recently, this link has been developed as a tool for classifying modules over certain minimal model vertex operator algebras, including the Virasoro, N=1 and affine sl(2) models. I will review this development and discuss our current efforts to extend it to higher rank minimal models.

Hermann Schulz-Baldes

Title. Spectral flow for real skew-adjoint Fredholm operators

Abstract. An analytic definition of a Z_2-valued spectral flow for paths of real skew- adjoint Fredholm operators is given. It counts the parity of the number of changes in the orientation of the eigenfunctions at eigenvalue crossings through 0 along the path. The Z_2-valued spectral flow is shown to satisfy a concatenation property and homotopy invariance, and it provides an isomorphism on the fundamental group of the real skew- adjoint Fredholm operators. Moreover, it is connected to a Z_2-index pairing for suitable paths. Applications concern the zero energy bound states at defects in a Majorana chain and a spectral flow interpretation for the Z_2-polarization in these models. Joint work with A. L. Carey and J. Phillips

Steve Siu

Title. Minimal models of the W3 Algebra

Abstract. The Virasoro algebra is the W-algebra associated to the affine sl(2) vertex operator algebra. Similarly, the W3 algebra is a W-algebra associated to the affine sl(3) VOA. In this talk we will first give a review on how one can obtain the irreducible modules of the Virasoro minimal models through screening operators. We will then discuss some examples as well as obstructions when one attempts to generalise this technique to the W3 minimal models.

Arthur Suvorov

Title. Topological properties of non-linear gravitational waves in modified gravity

Abstract. There is a wealth of evidence to suggest that, at least within the strong field or quantum regimes, the theory of general relativity (GR) breaks down. String theories, which attempt to bridge the gap between QFT and GR, often have low energy limits behaving like renormalized versions of GR, where additional curvature invariants couple to the Einstein-Hilbert action. Gravitational waves act as the energy transport mechanism (radiation) for time-varying gravitational fields, and are inherently nonlinear; linear waves cannot transport energy and momentum. The non-linear, hyperbolic nature of the field equations arising in non-Einstein theories implies that gravitational waves may behave very differently than they do in GR. We present some results concerning the structure of these waves (solitons) in a class of theories known as the f(R) gravities.

Guo Chuan Thiang

Title. From topological insulators to semimetals: some mathematical challenges

Abstract. The idea that insulating phases can be characterised by topological invariants is by now very well established. Semi-metallic phases, on the other hand, have only been experimentally realised and mathematically studied more recently. These phases have band crossings which are generally considered to be protected by some local topological charge, and are of great interest because of the possibility of realising exotic fermionic quasiparticles. I will explain how a global point of view helps in understanding the interplay between insulating and semi-metallic phases, and will also outline some mathematical challenges with regards to the semi-metallic bulk-boundary correspondence.

Ole Warnaar

Title. Hodge polynomials and Nekrasov-Okounkov

Abstract. In 2008 Hausel and Rodriguez-Villegas conjectured that the mixed Hodge polynomials of character varieties may be expressed in terms of Macdonald polynomials. In this talk I will describe how this is related to the work of Nekrasov and Okounkov on random partitions and to the equivariant Dijkgraaf-Moore-Verlinde-Verlinde formula.

Paul Zinn-Justin

Title. K-theory of the cotangent bundle of the Grassmannian and Razumov-Stroganov correspondence

Abstract. I'll try to present informally the connection between certain algebro-geometric data and quantum integrable systems, as we first accidentally discovered with P. Di Francesco and A. Knutson about 12 years ago, and was then rediscovered and expanded much further by Nekrasov and Shatashvili in the physics literature, and by Okounkov et al in the mathematics literature. After an overview of the simplest model in which this strategy applies (rational 5-vertex model), we shall discuss the more complicated case of the Temperley–Lieb loop model, how it relates to solutions of the quantum Knizhnik–Zamolodchikov equation, and ultimately the application to the ground state of the model with loop weight 1 and the Razumov–Stroganov correspondence.