Titles and Abstract
April 29, 2019

Michael Freedman, Microsoft Quantum – Santa Barbara, Shanks Lecture
Quantum Computation via Octonions

Abstract: I will explain how quantum computation can be carried out with quantum mechanical measurements (only); no explicit unitary transformations need be executed. There is a geometric requirement: "equiangularity" for not leaking quantum information. This leads to a search for large families of equiangular subspaces. The Octonions allow us to construct, in a sense, the largest possible family. Joint work with Shokrian-Zini and Wang.

Michael Freedman, Microsoft Quantum – Santa Barbara
Quantum Cellular Automata Beyond 1D

Abstract: I will discuss recent work on a fusion of foundational constructions in geometric topology and finite dimensional C*-algebras. The Kirby's torus trick and irregular covers enter on the side of topology, and Wedderburn's theorem on the algebra side. A new notion which may have some general promise, "visibly simple" arises. Joint work with Hastings.

Maissam Barkeshli, University of Maryland
Coupling fractons to topological quantum field theories and non-Abelian fractal quasiparticles

Abstract: The study of gapped quantum many-body systems in three spatial dimensions has uncovered the existence of quantum states hosting quasiparticles that are confined, not by energetics but by the structure of local operators, to move along lower dimensional submanifolds. These so-called ``fracton" phases are beyond the usual topological quantum field theory description, and thus require new theoretical frameworks to describe them. In this talk I will consider coupling fracton models to topological quantum field theories in (3+1) dimensions by starting with two copies of a known fracton model and gauging the symmetry that exchanges the two copies. This yields a class of exactly solvable lattice models with immobile non-Abelian quasiparticle excitations with position-dependent, robust degeneracies, and string excitations with geometry-dependent robust degeneracies.

Jonathan Belletete, PHT, Université Paris Saclay, CEA, CNRS
Topological defects in Temperley-Lieb lattice models

Abstract: Defects in integrable lattice models can be understood as boundaries separating two distinct (or not) phases, or sectors of a given model. We say it is topological if it can be continuously deformed without changing some relevant physical quantity, usually the partition function or the spectrum of some Hamiltonian operator.

The Temperley-Lieb algebras are a family of associative algebras used to build integrable lattice models, some of which are unitary, like the RSOS models and the associated anyon models, and some which are not unitary. I will explain how to realize topological defects in these models as functors acting on some category of representations. I will also explain how to use these functors

to impose specific integrable boundary conditions on lattice models; if time permits I will specifically discuss the twisted XXZ spin chain and the Fibonacci anyon chain.

Anna Marie Bohmann, Vanderbilt University
Loops, free loops, multiplication and comultiplication

Abstract: Algebraic structures---like multiplications---are powerful tools in understanding spaces. Unfortunately, most spaces don't have nice multiplications. Fortunately, the techniques of modern algebraic topology provide tools for working with algebraic structures "up to homotopy." We'll introduce these ideas in the classic example of based loop spaces, and then change perspective from multiplication to comultiplication to arrive at a new construction of free loop spaces. These are the main object of study in string topology. This new construction provides for lots of nice "up to homotopy" algebraic structure on free loop spaces. Ultimately, this structure descends to a new spectral sequence and should give calculational tools for understanding free loop spaces. This is joint work with Gerhardt, Hogenhaven, Shipley and Ziegenhagen.

Meng Cheng, Yale University
Boundary states of fermionic symmetry-protected topological phases

Abstract: Anomalous boundary states are hallmark of symmetry-protected topological (SPT) phases. In this talk we examine boundaries of fermionic SPT phases described by group super-cohomology models in both (2+1)d and (3+1)d. In particular we focus on those fermionic SPT phases that are only enabled by strong interactions. To construct models for boundary excitations we exploit a correspondence between SPT phases protected by internal symmetries and those by spatial symmetries. Two examples will be discussed: 1. topologically ordered surface states of (3+1)d fermionic SPT phases and 2. gapless edge states of a (2+1)d fermionic SPT phase.

Iris Cong, Harvard University
Universal Quantum Computation with Gapped Boundaries

Abstract: In this talk, I will discuss topological quantum computation with gapped boundaries of two-dimensional topological phases. I will first introduce the algebraic framework for topological quantum computation and gapped boundaries. Next, I will present systematic methods to encode quantum information topologically using gapped boundaries, and to perform topologically protected operations on this encoding. In particular, I will introduce a new computational primitive of topological charge measurement and present a symmetry-protected implementation of this primitive. Throughout the talk, a concrete physical example - the case of bilayer fractional quantum Hall 1/3 systems [mathematically, D(Z_3)], will be discussed. For this example, we have a qutrit encoding and an abstract universal gate set. If a practical implementation is found for the required topological charge measurement, these boundaries will give rise to a direct physical realization of a universal quantum computer based on a purely Abelian topological phase.

Colleen Delaney, UCSB
Algebraic theory of bilayer symmetry defects and TQC

Abstract: We describe how to construct algebraic data for the family of SET phases that come from bilayer (2+1)-D topological order enriched with layer-exchange symmetry. We outline a general theory and give examples of bilayer defect models in terms of G-crossed braided extensions of modular tensor categories and discuss the implications for topological quantum computing, gauging, and the Property F conjecture.

In particular, we prove that exchange of bilayer symmetry defects cannot generate universal quantum computation if braiding of the underlying monolayer anyons is not universal. This talk is based on joint work with Eric Samperton.

Lukasz Fidkowski, University of Washington
Non-trivial quantum cellular automata in 3 dimensions

Abstract: Motivated by studying the entanglement structure of certain symmetry protected topological phases, we construct a non-trivial quantum cellular automaton in a Hilbert space fora 3d lattice of spin 1/2 degrees of freedom. This is an operator which takes local operators to nearby local operators, but is not locally generated. We discuss implications for the classification of SPT phases in equilibrium and Floquet settings

Cameron Gordon, University of Texas, Austin
ADE links and cyclic branched covers

Abstract: It is well known that the Dynkin diagrams of types A, D and E arise in many classification problems in mathematics. We suggest a modest addition to this list: the fibered links that induce the standard contact structure on S^3 and have some cyclic branched cover a Heegaard Floer L-space. This is joint work with Michel Boileau and Steve Boyer.

Sergei Gukov, Caltech and MPI Bonn
MTCs, SPTs, and TMFs

Dan Harlow, MIT
Symmetry in quantum field theory and gravity

Abstract: It has long been suspected that global symmetries are impossible in quantum gravity. In this talk I'll describe how within the AdS/CFT correspondence one can use algebraic methods to demonstrate this, and I will also comment on the implications of this result for quantum error correcting codes.

Matthew Headrick, Brandeis University
Holography and Entanglement

Abstract: I will give a very brief introduction to holography and the AdS/CFT correspondence, which relate quantum gravity theories to quantum field theories. I will then explain an intimate relationship between quantum entanglement and spacetime geometry revealed by this correspondence.

Corey Jones, The Ohio State University
Spontaneous symmetry breaking from anyon condensation

Abstract: The algebraic theory of anyons in a 2-dimensional topological phase of matter is characterized by a unitary modular tensor category C. One type of continuous transition between such phases is anyon condensation, which at the categorical level is described by taking local modules of a commutative algebra object A. The presence of a group of global symmetries on the system yields a G-crossed braided extension of C, characterizing the algebraic theory of symmetry defects. In this talk, we will explain the interaction between global symmetry and anyon condensation at the categorical level. In particular, we describe necessary conditions for symmetry to be preserved under anyon condensation in terms of splittings of a certain short exact sequence, and show that this data is sufficient to coherently construct a G-crossed braided extension of the condensed phase. Based on joint work with Marcel Bischoff, Yuan-Ming Lu, and David Penneys.

Vaughan Jones, Vanderbilt University
Discrete scale invariance in quantum spin chains - a proposed experiment

Abstract: We will discuss a group of local scale transformations on a quantum spin chain. We will show how the existence of scale invariant states inside a Hilbert space on which the group of local scale transformations acts unitarily. These highly non-local states exhibit a strange auto-correlation phenomenon which suggests an experiment to see if they ever get excited at a quantum phase transition.

Slava Krushkal, University of Virginia
Applications of TQFT to classical and quantum graph polynomials

Abstract. This talk will outline a circle of ideas at the intersection of topological quantum field theory, combinatorics, and lattice models in statistical mechanics. I will explain how the structure of (2+1)-dimensional TQFT gives rise to a conceptual framework for studying planar triangulations. More generally, applications will be given to the structure of classical and quantum polynomial invariants of graphs. This talk is based on joint works with Paul Fendley and with Ian Agol.

Zhengwei Liu, Harvard University & Tsinghua University
Quantum Fourier Analysis

Abstract: We propose a program Quantum Fourier Analysis to investigate the analytic aspects of quantum symmetries and their Fourier dualities. We introduce a topological analogue of the Brascamp-Lieb inequality. We review some recent results and propose future research directions.

Ashley Milsted, Perimeter Institute
Emergence of conformal symmetry in critical quantum spin chains and tensor networks

Abstract: That the low-energy physics of critical quantum spin chains (1+1D) is often described by a conformal field theory (CFT) is well established and it is well-known that the CFT can often be identified numerically by exploiting the emergent conformal symmetry in low-energy eigenstates of the system Hamiltonian. In the 90's, Koo & Saleur demonstrated that this emergence extends to approximate realizations, acting on the spin-chain Hilbert space, of the Virasoro generators of 2D conformal symmetry.

We show that these operators, which are constructed from the system Hamiltonian, can be used to systematically identify low-energy eigenstates with CFT scaling operators, including in generic (non-integrable) models. Using this identification, we show that conformal transformations also emerge in certain tensor networks describing critical ground states; namely the MERA and the Euclidean path-integral tensor network. In particular, their component tensors can be combined to build linear maps that approximate the action of arbitrary conformal transformations on the spin-chain Hilbert space.

Scott Morrison, Australian National University
Algebras in higher categories

Abstract: (This is the first part of a two talk series --- Kevin Walker will continue on Sunday).
I will sketch a definition of a higher dimensional algebra in a higher category. We'll begin with an informal description of higher categories via string diagrams, give the general definition, and then verify the slightly non-obvious facts that this definition recovers the notion of an idempotent in dimension 1, and an associative algebra in dimension 2.

In fact, higher algebras in an n-category form an n-category, which is naturally viewed as a type of completion. This completion has some excellent properties; the inclusion is a Morita equivalence, and a pair of categories are Morita equivalent precisely if their completions are (functorially) equivalent.

Kevin's continuation will explain how this picture gives rise to state-sum models for TQFTs, and give a generalisation of Ostrik's theorem: any (n-1)-dimensional module category for an n-category can be realised as the modules for some n-dimensional algebra.

Robert McRae, Vanderbilt University
Twisted modules and G-equivariantization in logarithmic conformal field theory

Abstract: Logarithmic conformal field theories are conformal field theories which admit correlation functions with logarithmic singularities. Such singularities arise as a consequence of non-semisimplicity in the representation category of the vertex operator algebra associated to the theory. In this talk, I will consider the action of a finite group G on a vertex operator algebra V for which the vertex operator subalgebra V^G of G-fixed points admits a possibly non-semisimple braided tensor category structure. The main result is that every V^G-module which admits a suitably associative left action of V is a (direct sum of) so-called g-twisted V-modules

for certain g in G. An application is that induction yields a braided tensor equivalence from the category of V^G-modules to the G-equivariantization of the braided G-crossed category of twisted V-modules. These results are proved using diagrammatic techniques for braided tensor categories, and they generalize theorems of Muger and Kirillov proved in the case that the category of V^G-modules is a semisimple modular tensor category.

Yoshiko Ogata, The University of Tokyo
Classification of symmetry protected topological phases in quantum spin chain

Abstract: For the classification of SPT phases, defining an index is a central problem. In the famous paper [PTBO1], Pollmann, Tuner, Berg, and Oshikawa introduced ${\mathbb Z}_2$-indices for injective matrix products states (MPS) which have either ${\mathbb Z}_2\times {\mathbb Z}_2$ dihedral group (of π-rotations about x, y, and z-axes) symmetry, time-reversal symmetry, or reflection symmetry. We introduce an index which generalizes the index by Pollmann et al. The index is an invariant of the C^1-classification of SPT phases.

Tobias Osborne, Leibniz University Hannover
Quantum fields for unitary representations of Thompson's groups F and T

Abstract: I will describe how to define observables analogous to quantum fields for the semicontinuous limit recently introduced by Jones in the study of unitary representations of Thompson's groups F and T. One finds that, in terms of correlation functions of these fields, one can deduce quantities resembling the conformal data, i.e., primary fields, scaling dimensions, and the operator product expansion. Examples coming from quantum spin systems and anyon chains built will be discussed.

Vincent Pasquier, IPhT Saclay
Classical versus Quantum Dynamics

Abstract: I present results on the dynamics of the XXZ spin chain prepared with a domain wall and compare them with the classical dynamics of the Landau Lifshitz model. In paricular, I compare some DMRG results with some exact results in the diffusive short time regime. I might also comment on the similar problem witha stochastic dynamics and the Toda chain dynamics. Based on work in progress with Gregoire Misguich and Nicolas Pavloff.

David Penneys, Ohio State University
G-graded extensions of braided enriched fusion categories

Abstract: In joint worth with Morrison, we introduced the notion of a monoidal category enriched in a braided monoidal category V, and we classified these objects in terms of braided central functors from V into the Drinfeld centers of ordinary monoidal categories. Since, braided enriched fusion categories have been useful in the work of Kong and Zheng on gapless boundaries for 2D topological orders. On the other hand, G-extensions of fusion categories are important for the study of symmetry enriched topological orders. In this talk, I will discuss work-in-progress with Corey Jones, Scott Morrison, and Julia Plavnik on the structure of G-graded

extensions of braided enriched fusion categories, along with an obstruction theory for classifying such G-extensions in the spirit of Etingof, Nikshych, and Ostrik.

Emily Peters, Loyola University Chicago
New fusion categories in the Morita equivalence class of extended Haagerup

Abstract: The extended Haagerup subfactor has two even parts EH1 and EH2. These fusion categories are currently the only known fusion categories which cannot be constructed from groups, quantum groups, or Izumi quadratic categories. One key technique which has previously revealed hidden structure in fusion categories is to study all other fusion categories in the Morita equivalence class and hope that one of the others is easier to understand. In joint work with Grossman, Morrison, Penneys and Snyder, we found that there are at most two more fusion categories in the extended Haagerup Morita equivalence class, that there is a unique Morita equivalence between each, and that no others exists. Neither EH3 nor EH4 seems easy to understand directly, which gives further evidence that extended Haagerup does not come from known constructions.

Julia Plavnik, Indiana University
An overview of gauging symmetry of modular tensor categories

Abstract: Constructing modular tensor categories is an important and hard task. Gauging symmetries of modular tensor categories is one way to produce new modular tensor categories from a given modular tensor category with a topological symmetry on it.

In this talk, we will begin by recalling the mathematical definition of this construction. We will also present some examples and properties of this procedure. We will finish the talk discussing some open questions and directions of study related to gauging. If time allows, we will mention some work in progress related to zesting and gauging.

Modjtaba Shokrian Zini
Hopf monads and generalized symmetries of fusion categories

Abstract: Hopf monads in monoidal categories are a generalization of the notion of categorical Hopf algebras which are defined only in braided categories. I will go over the definition, then explore the possible role they might play for a generalization of group symmetries of fusion categories. The ultimate goal is to derive the extension theory needed to study the classification of fusion categories. Likely, a similar extension theory should exist for the richer modular categories. This could be the missing extension theory allowing us to investigate successfully the (non-)exoticness of the famous Haagerup fusion category.

James Tener, Australian National University
A unified perspective on 2d chiral CFT

Abstract: There are two heavily studied axiomatizations of 2d unitary chiral conformal field theory: unitary vertex operator algebras and conformal nets. These notions are expected to be equivalent under some mild hypotheses, but providing a rigorous mathematical argument has proven to be a challenging task. In this talk, I will show how the notion of functorial conformal field theory (in the sense of Segal) can be modified contain both the data of a vertex operator algebra and a conformal net. I will also discuss how to use functorial and geometric notions to approach the problem of establishing equivalence between VOAs and conformal nets.

Kevin Walker, Microsoft Station Q (Santa Barbara)
n-category completions, an Ostrik theorem for n-category modules, and classifying symmetry enhanced phases

Abstract: This is joint work with Scott Morrison, and also a continuation of his talk. Ostrik's theorem establishes a relationship between module categories for tensor categories and algebra objects in a tensor category, allowing us to classify one in terms of the other. I'll describe a generalization of Ostrik's theorem for n-categories and their modules, which again can be viewed as a classification result. Symmetry-enhanced topological phases (SETs) can be thought of as modules for the fundamental n-groupoid of BG (classifying space of a finite group G). Thus we get a classification of SETs in terms of higher-dimensional algebra objects in \pi_{\le n}(BG).

Zhenghan Wang, Microsoft Station Q – UCSB
Beyond anyons: from fractons to black holes

Abstract: Anyons characterize intrinsic two dimensional topological phases of matter and are modelled mathematically by unitary modular categories. The mathematical theory of anyons is relatively mature, so it is interesting to look for generalizations. I will discuss fracton models generalizing Haah codes, which harbor anyon-like excitations called type II fractons, based on joint work with K. Tian and E. Samperton. If time permits, I will also discuss BTZ black holes in pure (2+1)-quantum gravity as generalized anyon objects.

Shmuel Weinberger, University of Chicago
Lipschitz constants and geometric complexity

Abstract: The success of algebraic topology in exploring (nonlinear) function spaces is astounding. In order to try to discover if there is a geometric reason for this success, it is natural to study the Morse landscape of natural functionals on this space. We consider the Lipschitz constant, as it is a natural measure of complexity, and also generalizes the classical theory of closed geodesics. I will describe recent work by Chambers, Dotterer, Manin and myself about this, and its implications for understanding the geometric nature of solutions of topological problems -- that often go by way of "reduction to algebraic topology".

Tim Ziman, Institut Laue-Langevin, Universite de Grenoble and CNRS
Transformation of currents and critical spin fluctuations

Abstract: One of the current concerns in condensed matter physics is to find efficient ways of transforming between different physical currents. For example, we might want to transform a charge current to a spin current, or a charge current to a heat current or back again. There are various mechanisms to do so but many are rather weak, often depending on relativistic interactions. In some cases spin fluctuations may contribute to the conversion and it is then natural to look at physical systems where the fluctuations are enhanced by proximity to a critical point, low spatial dimensions or competition between different possible forms of order. I will discuss this in the light of recent theory and experiments in solid state systems, involving spins and correlated electrons close to a phase transition.