Guifre Vidal, Perimeter Institute
Tuesday, October 2, 2012, 3:00 pm, 107 Annenberg
Starting from a microscopic Hamiltonian on an infinite cylinder, In Ref. [Cincio and Vidal, "Characterizing topological order by studying the ground states of an infinite cylinder", arXiv:1208.2623v1], a method to obtain a tensor network representation for the different ground states of a topologically ordered system was proposed. In this talk, I will review that approach and explain how to also obtain a tensor network representation for each of the different quasi-particle excitations of the emergent, topologically ordered medium, including those with fractionalized quantum numbers.

Quantum mechanics, cosmology, and self-locating uncertainty
Sean Carroll, Caltech
Tuesday, October 9, 2012, 3:00 pm, 107 Annenberg

A longstanding issue in attempts to understand the Everett (Many-Worlds) approach to quantum mechanics is the origin of the Born Rule: why is the probability given by the square of the amplitude?

Recently, Page has raised another puzzle: the Born Rule itself is insufficient in cases where the wave function includes multiple indistinguishable observers in the same branch. We argue that both problems share a common solution, arising from a proper treatment of self-locating uncertainty (physical situations containing multiple copies of identical observers). This analysis gives a simple, physics-oriented derivation of the Born Rule, as well as a justification for the treatment of identical classical observers.

Topological order with tensor networks on infinite cylinders: an explicit wavefunction for fractionalized quasi-particle excitations

A classical leash for a quantum tiger: Key distribution with miminmal assumptions
Ben Reichardt, University of Southern California
Tuesday, October 16, 2012, 3:00 pm, 107 Annenberg

Can an experimentalist possibly understand and control an arbitrary quantum system? We give a scheme by which a classical experimentalist, with only classical interactions, can fully control black-box quantum-mechanical systems. The scheme even distinguishes a quantum computer from a classical simulation.

Although partly philosophical, this result has cryptographic applications. The original idea of quantum key distribution (QKD) is to base security on the laws of physics. But in practice QKD systems have been attacked, because real devices deviate from the mathematical models. Mayers and Yao in 1998 suggested that perhaps all these side-channel attacks could be eliminated. Barrett, Hardy and Kent gave the first "device-independent" QKD security proof in 2005, based on the assumption that Alice and Bob

each have n devices, that are separately kept isolated but are otherwise arbitrary. We prove security with just one device for Alice and one for Bob. The key theorem studies sequential composition of a two-player game, and argues that nearly optimal strategies are nearly uniquely determined.
As another corollary, QMIP = MIP*.

Based on arXiv:1209.0448 and 1209.0449. Joint work with Falk Unger and Umesh Vazirani.

Efficient distributed quantum computing
Steve Brierley, University of Bristol
Tuesday, October 23, 2012, 3:00 pm, 107 Annenberg

I'll present algorithms for efficiently moving and addressing quantum memory in parallel. These imply that the standard circuit model can be simulated with low overhead by the more realistic model of a distributed quantum computer. In addition, our results apply to existing memory intensive quantum algorithms. I'll show you a new parallel quantum search algorithm and explain how to improve the time-space trade-off for the Element Distinctness and Collision problems.

Topological stabilizer codes with a power law energy barrier via welding
Kamil Michnicki, University of Washington
Tuesday, October 30, 2012, 3:00 pm, 107 Annenberg

A high energy barrier for logical errors is essential for the development of self-correcting quantum memories in the Hamiltonian framework. These devices would have an unbounded storage time at a fixed temperature as a function of the total number of qubits. In order to find a codes with large energy barriers we introduce a new primitive, called welding, for combining two stabilizer codes to produce a new stabilizer code for which the resulting shape of the logical operators is the combination of the former two shapes. We apply welding to construct surface codes and then use the surface codes to construct solid codes, a variant of a 3-d toric code with rough and smooth boundaries. Finally, we weld solid codes together to produce a [O(L^3),1,O(L^{4/3})] stabilizer code with an energy barrier of O(L^{2/3}), which solves an open problem of whether a power law energy barrier is possible for local stabilizer code Hamiltonians in three-dimensions. The previous highest energy barrier is O(log L)$. Previous no-go results are avoided by breaking translation invariance. Despite the large energy barrier, this code is unlikely to serve as a self-correcting quantum memory.

Emergence and frustration of Magnetism in a trapped ion quantum simulator
Wes Campbell, UCLA
Tuesday, November 20, 2012, 3:00 pm, 107 Annenberg

Frustration, or the competition between interacting components of a network, is often responsible for the complexity of many body systems. In quantum magnetic systems, frustration arises naturally from competing spin-spin interactions given by the geometry of the spin lattice or by the presence of long-range antiferromagnetic couplings. I will describe work using a trapped atomic ion quantum simulator to simulate strongly-coupled, frustrated quantum systems with up to 16 spins. We control the amount of frustration in the system by continuously tuning the range of an antiferromagnetic coupling in a linear spin chain, and we examine the dynamics and magnetism of the system as it crosses the critical point. In the future, quantum simulations such as these may to shed light on universal behavior of many-body systems in the quantum regime.

On the structure of symmetric quantum measurements
Jon Yard, Microsoft Station Q
Tuesday, December 11, 2012, 3:00 pm, 107 Annenberg

A central problem in quantum information theory is to understand the apparent existence of d^2 equiangular lines in any d-dimensional complex vector space. Such configurations of lines determine highly-symmetric optimal quantum measurements known as Symmetric Informationally-Complete Positive Operator-Valued Measures (SIC-POVMs). Much evidence indicates that SIC-POVMs can always be obtained as special orbits of finite Heisenberg groups. Exact constructions of Heisenberg-covariant SIC-POVMs are currently known in 22 different dimensions, while numerical evidence indicates that they exist for every dimension up to 67. The elements of Heisenberg-covariant SIC-POVMs correspond to quantum states that are maximally localized in discrete phase space and can be viewed as finite-dimensional analogs of coherent states. They also contain rich algebraic structure, as they are defined over number fields with nonabelian Galois groups - namely, over abelian extensions of quadratic fields. In this talk, I will show how the mathematics of class field theory can explain some of the group-theoretic structure possessed by these known examples while offering predictions for their structure in arbitrary dimensions.