APPLIED MATHEMATICS COLLOQUIUM

"Topological Phases of Matter: Modeling and Application to Quantum Computing"

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Abstract:
Topological phases of matter are exotic quantum states of matter that possess an elusive order, dubbed topological order by X.-G. Wen. Elementary excitations in topological phases of matter are quasi-particles, named anyons by F. Wilczek, which obey neither bosonic nor fermionic statistics. Modeling of two dimensional topological phases of matter utilizes a diverse variety of mathematics: (2+1)-topological quantum field theory as effective theory, conformal field theory as edge theory, and modular tensor category as an algebraic theory of anyons. A topological phase of matter that harbors non-abelian anyons is essentially a topological quantum computer, immune to local errors, and thus provides a realization of fault-tolerant quantum computation.

In this survey talk, we will start with the only currently known examples of topological phases of matter---fractional quantum Hall liquids--and explain their theoretical models. The effective theories of fractional quantum Hall liquids are the quantum Witten-Chern-Simons theories, and the major components of the modeling ground state wave functions of quantum Hall liquids are translation-invariant symmetric polynomials with an arbitrary number of variables (most such polynomials occur as conformal blocks of the conformal field theories which describe the edges). Next, we will discuss how quantum computing is carried out by braiding non-abelian anyons. We will address when braiding alone can lead to universal quantum gates and hence Shor's factoring algorithm can be implemented by a topological quantum computer. Finally, we conjecture that the failure of the universality of braiding gates is related to a form of explicit locality in topological quantum field theory involving the Yang-Baxter equation.

Monday April 4th, 2011
4:30 PM
Building 2, Room 105

Refreshments are available in Building 2, Room 290
(Math Common Room) between 3:30 – 4:30 PM

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