MAR07-2006-006863
Abstract for an Invited Paper
for the MAR07 Meeting of
the American Physical Society

Toplogical Quantum Compiling

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A quantum computer must be capable of manipulating quantum information while simultaneously protecting it from error and loss of quantum coherence due to coupling to the environment. Topological quantum computation (TQC) offers a particularly elegant way to achieve this. In TQC quantum information is stored in exotic states of matter which are intrinsically protected from decoherence, and quantum computation is carried out by dragging particle-like excitations (quasiparticles) around one another in two space dimensions. The resulting quasiparticle trajectories define world-lines in three-dimensional space-time, and the corresponding computation depends only on the topology of the braids formed by these world-lines. A variety of proposed fractional quantum Hall states are believed to possess quasiparticles that can be used for TQC – among them the so-called "Fibonacci anyons". These quasiparticles are conjectured to exist in the experimentally observed $\nu = 12/5$ fractional quantum Hall state. In this talk, I will review the basic ideas behind TQC, and describe our recent work showing explicitly how to translate (compile) arbitrary quantum algorithms into specific braiding patterns for Fibonacci anyons. (Work done in collaboration with N.E. Bonesteel, S.H. Simon, and G. Zikos.)