Topological Quantum Compiling

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Abstract. In a topological quantum computer (TQC), quantum information is stored in "topological states of matter" (realizations of topological field theories) which are intrinsically protected from decoherence, and quantum gates (computations) are carried out by dragging particle-like excitations (quasiparticles) around one another in two space dimensions. The resulting quasiparticle trajectories define world-lines in 2+1 dimensional space-time, and the corresponding quantum gates depend only on the topology of the braids formed by these world-lines. This connection between braiding world lines and quantum compuation stems from the deep connection between quantum field theories and knot invariants. While this idea seems rather abstract and exotic, there is mounting evidence that such states of matter do exist in quantum Hall systems and the effort to harness their properties for this type of quantum computation is rapidly mounting. In this talk I will review the field of topological quantum compuation and I will show how quantum compuations are mapped to particular world-line braids, thus "compiling" a quantum computation into "machine language" instructions.