

A Tale of Quantum Computation and Categorification

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Quantum topology is the branch of mathematics that connects entanglement in quantum mechanics with topological entanglement in low-dimensional topology, such as the knotting, tangling, and linking of strings in 3d space. At its core lie Artin's braid groups, algebraic structures that capture the rules of intertwining strands. These same structures underpin topological quantum computation, where braids guide the motion of quasiparticles in 2d, and quantum information is stored in global topological features that make it resistant to local errors. Pushing further, categorification lifts these algebraic ideas to higher-dimensional structures, allowing us to track the movements of strings in 4d and uncover hidden symmetries. Along the way, surprising bridges emerge to both physics and computer science. I will illustrate these themes through an accessible mathematical example.

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