Quantum Physics

Simulations of quantum double models

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We demonstrate how to build a simulation of two dimensional physical theories describing topologically ordered systems whose excitations are in one to one correspondence with irreducible representations of a Hopf algebra, D(G), the quantum double of a finite group G. Our simulation uses a digital sequence of operations on a spin lattice to prepare a ground "vacuum" state and to create, braid and fuse anyonic excitations. The simulation works with or without the presence of a background Hamiltonian though only in the latter case is the system topologically protected. We describe a physical realization of a simulation of the simplest non-Abelian model, D(S_3), using trapped neutral atoms in a two dimensional optical lattice and provide a sequence of steps to perform universal quantum computation with anyons. The use of ancillary spin degrees of freedom figures prominently in our construction and provides a novel technique to prepare and probe these systems.

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