Contribution Title: TOPOLOGICAL ORDER IN QUANTUM LATTICE MODELS
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We investigate quantum lattice models that are believed to form topologically ordered states known also as topological phases. Our particular focus is on the Kitaev honeycomb spin-1/2 lattice model [1]. In the absence of external magnetic field, the model is exactly solvable and its phase diagram exhibits a gapless phase and an abelian topological phase whose effective description is given by the Z2 x Z2 topological field theory. As known from the perturbation theory, a weak magnetic field has no dramatic effect on the abelian topological phase but turns the gapless phase into a non-abelian topological phase whose effective description is given by the Ising topological field theory. The quasiparticle excitations of this phase are nonabelian anyons satisfying the Ising fusion rules.

We particularly study the Kitaev honeycomb lattice on torus [2]. We describe symmetries of this model and review the perturbative mapping of its abelian topological phase onto the Z2 x Z2 square lattice model known as the toric code. We provide the classification of finite size effects on the model low-energy spectral properties [3]. In this context, special attention is given to the thin-torus limit and related conformal field theory data. We then investigate properties of the model's vortex excitations and complete with discussion of topological degeneracy of the model and the effect of the magnetic field [2,4].

We conclude with a brief review of other lattice models whose low energy spectra provide realization of topological field theories and outline applications of topologically ordered systems for quantum information processing.

[1] A. Kitaev, Ann. Phys. 321, 2 (2006).

[2] G. Kells et al., Phys. Rev. Lett. 101, 240404 (2008).

[3] G. Kells et al., J. Stat. Mech. – Theory Exp. P03006 (2009).

[4] V. Lahtinen et al, Ann. Phys. 323, 2286 (2008).