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Spin liquid phases in exactly solvable models: proof of principle

HONG YAO

"Spin liquids" are elusive quantum states of matter, characterized by topological order and a spectrum of fractionalized excitations rather than by broken symmetries. As the study of spin-liquids is still in a formative stage, it is useful to construct exactly solvable models with various flavors of spin liquid ground state so as to establish their stability as phases of matter and to derive essential features of their physical properties. Here we study three such models: Firstly, we show that two distinct chiral spin liquid phases are realized in a spin-1/2 Kitaev model on a decorated honeycomb lattice (also know as the star lattice). Depending on coupling parameters, its vortex excitations (visons) obey Abelian or non-Abelian statistics. The quantum phase transition between the two phases, although purely topological, is never-the-less continuous. Secondly, we introduce a spin-3/2 Kitaev-like model on the square lattice. This model has a "half-integer" spin per unit cell, and an algebraic spin liquid ground state. Remarkably, by fine-tuning some parameters in this spin-3/2 model, fermionic excitations with an emergent Fermi surface can be realized. Thirdly, we establish genuine spin-charge separation in an extended Hubbard model of electrons on the Kagome lattice. We show how this extended Hubbard model potentially can be realized in ultra-cold gases with dipolar interactions.