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Chiral spin liquid in the frustrated XY model on the honeycomb lattice

TIGRAN SEDRAKYAN, Fine Theoretical Physics Institute, University of Minnesota and Physics Frontier Center, Joint Quantum Institute, University of Maryland

A honeycomb lattice allowing hops between nearest- and next-nearest neighbors hosts "moat" bands with degenerate energy minima attained along closed lines in Brillouin zone. If populated with hard-core bosons, a variety of unconventional ground states stabilizes. We argue that the degeneracy prevents Bose condensation, stabilizing novel spin liquid phases including composite fermion state and a chiral spin liquid. The latter stabilizes at half-filling, when the system is equivalent to $s = 1/2$ XY model at zero magnetic field. Absence of condensation means no spontaneous polarization in XY plane, however our consideration indicates formation of a state spontaneously breaking the time-reversal symmetry. This state has a bulk gap and chiral gapless edge excitations, and is similar to the one in Haldane's "quantum Hall effect without Landau levels" in its topologically nontrivial sector with Chen number $C = \pm 1$. The applications of the developed analytical theory include an explanation of recent unexpected numerical findings and a suggestion of a chiral spin liquid realization in experiments with cold atoms in optical lattices.