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