Projected wave function study of $Z_2$ spin liquids on the kagome lattice for the spin-1/2 quantum Heisenberg antiferromagnet

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Within the class of Gutzwiller projected fermionic wave functions, by using quantum variational Monte Carlo simulations, we investigated the energetics of all possible $Z_2$ spin liquids that can potentially occur as ground states of the nearest-neighbor $S=1/2$ quantum Heisenberg model on the Kagome lattice [1]. We conclusively show that all gapped and gapless $Z_2$ spin liquids are higher in energy compared to the U(1) gapless states in whose neighborhoods they lie. In particular, the most promising gapped $Z_2$ spin liquid (the so-called $Z_2[0,\pi/\beta]$ state), conjectured to describe the ground state [2], is always higher in energy compared to the U(1) Dirac spin liquid. We also extended the U(1) Dirac state and the uniform RVB spin liquid to include next-nearest-neighbor hopping terms, and studied its local and global stability towards various valence bond crystal patterns. We found that a non-trivial 36-site VBC is stabilized upon addition of a small ferromagnetic exchange coupling [3].


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