Quantum Spin Liquid Physics on a novel shuriken lattice based material

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The search for quantum spin liquids is one of the most hotly pursued endeavors in condensed matter physics. In two-dimensions, corner-sharing triangular geometries such as the kagome lattice have proved to be a fertile ground in realizing these exotic phases of quantum matter. In this talk, I will discuss the novel shuriken lattice geometry as an ideal playground for realizing quantum spin liquids, being motivated by its recent first of a kind experimental realization in the spin $S = 1/2$ system $KCu_6AlBiO_4(SO_4)_5Cl$. Towards understanding the rich quantum phase diagram of Heisenberg spins on the shuriken lattice, we employ state-of-the-art quantum many-body numerical techniques such as variational Monte Carlo (VMC) with versatile Gutzwiller-projected Jastrow wave functions, unconstrained multi-variable variational Monte Carlo (mVMC), and pseudo-fermion/Majorana functional renormalization group (PF/PM-FRG) methods. We establish the presence of a quantum paramagnetic ground state and investigate its nature, by classifying symmetric and chiral quantum spin liquids, and inspecting their instabilities towards competing valence-bond-crystal (VBC) orders. Our VMC analysis reveals that a VBC with a pinwheel structure emerges as the lowest-energy variational ground state, and it is obtained as an instability of the $U(1)$ Dirac spin liquid. Analogous conclusions are drawn from mVMC calculations employing accurate BCS pairing states supplemented by symmetry projectors, which confirm the presence of pinwheel VBC order by a thorough analysis of dimer-dimer correlation functions. Our work highlights the nontrivial role of accounting for further neighbor Heisenberg and/or Dzyaloshinkii-Moriya interactions towards explaining the experimental observations.

Reference:

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