SU(4)-symmetric spin-orbital liquids on the hyperhoneycomb lattice

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The physics emerging from the interplay between strong correlations and spin-orbit coupling has stimulated the research of transition metal oxides with 4d or 5d elements. One can argue that the most important discovery in this context was that the exactly solvable Kitaev model is relevant to describe the magnetism of these Mott insulators with $4/5d^5$ in edge-sharing octahedral geometries. When the Kitaev model is implemented on tricoordinated lattices, one can easily integrate it through a Majorana parton representation of the spins and show that its ground state is a quantum spin liquid (QSL). Compounds that are correctly modeled by a dominant Kitaev model were synthesized and are called Kitaev materials. However, the QSL phase was still not realized because of additional interactions that tend to drive these systems to different ordered states. In this talk, we report our study on an alternative route to QSLs. We first derive the effective spin-orbital model that describes the magnetism of $4d^1$ or $5d^1$ Mott insulators in the same octahedral environment of the Kitaev materials. In the limit of vanishing Hund’s coupling, the model has an emergent SU(4) symmetry which is made explicit by means of a Klein transformation on pseudospin degrees of freedom. Taking the hyperhoneycomb lattice as an example, we employ parton constructions with fermionic representations of the pseudospin operators to investigate possible quantum spin-orbital liquid states. We show the results of the variational Monte Carlo computations to the energies of the projected wave functions. These numerical results show that the lowest-energy quantum liquid corresponds to a zero-flux state with a Fermi surface of four-color fermionic partons.