

Z_2 projective symmetry group study of strongly spin-orbit coupled pyrochlore materials

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We give a complete classification of Z_2 spin liquid states in the pyrochlore lattice using the projective symmetry group (PSG) approach. A list of mean field Hamiltonians is obtained for the PSG classes. By studying the spin liquid–magnetic order transition we establish the phase diagrams for these mean field theories, which link magnetic orders to specific spin liquids. Crucially, we find the existence of additional hidden orders that break inversion symmetry and the coexistence of different orders required by the PSG mean field theories. At the spin liquid–magnetic order transition points, the low energy theories are categorized into $z = 1$ and $z = 2$ types according to dispersion and Hamiltonian diagonalizability, which can be distinguished from properties of structure factors and heat capacity exponent. The effects of strong spin-orbit coupling are also discussed. This study provides a clear map between spin liquid and magnetic phases of pyrochlore, which can be used for future experiments and variational Monte-Carlo studies of the pyrochlore materials.