1. Introduction

- One of the prime theoretical interests in frustrated quantum magnets lies in the possibility that they might exhibit disordered quantum paramagnetic states and/or spin liquid behaviour. Among the most highly frustrated systems are those composed of tetrahedra coupled into 2D or 3D lattice networks. Prominent among the latter are the pyrochlores, whose basic structure is one of vertex-sharing tetrahedra.

- Using the coupled cluster method (CCM) we study the zero-temperature ground-state phase diagram of the spin-$\frac{1}{2}$ Ising antiferromagnet on the checkerboard lattice. In turn, we find that these states become infinitely susceptible to CDVBC ordering for $1/4 < \kappa < 1$.

2. The $J_1$-$J_2$ checkerboard model

- The model is explicitly described as a frustrated $J_1$-$J_2$ Ising antiferromagnet (IFM) on the 2D checkerboard lattice, with nearest-neighbour exchange bonds of strength $J_1 > 0$ and next-nearest-neighbour bonds of strength $J_2 > 0$.

- Special cases:
  - $\kappa = 0$ → square-lattice HAFM
  - $\kappa = 1$ → isotropic checkerboard lattice HAFM
  - $\kappa = \infty$ → decoupled 1D HAFM chains

- Energy scale: Henceforth we set $J_1 \equiv 1$.

- Classical ground states:
  - $\kappa < 1$ → Néel state
  - $\kappa = 1$ → checkerboard state
  - $\kappa > 1$ → decoupled 1D HAFM chains

3. CCM Formalism

- General formalism

$$H^{(\kappa)}(\delta) = E^{(\kappa)}(\delta); \quad \langle \Phi| \tilde{H}^{(\kappa)}| \Phi \rangle = 0; \quad \langle \Phi| \tilde{H}^{(\kappa)}| \Phi \rangle = 0, \quad \forall \delta \neq 0; \quad \forall \delta \neq 0$$

- Specific formalism for quantum spin-lattice systems

4. Ground-State Energy and Magnetization ($J_1 = 1$)

- Our calculations show that the AFM classical state with Néel ordering is the gs phase for $\kappa < \kappa_c \approx 0.90 \pm 0.01$, but that neither the striped nor Néel$^\prime$ states that form the gs phase for the classical version $\kappa \rightarrow \infty$ of the model (for $\kappa > 1$) survive the quantum fluctuations to form a stable magnetically-ordered gs phase for the $\kappa \rightarrow 1$ case.

5. Valence-Bond Crystal (VBC) Susceptibilities

- References


Acknowledgment

We thank the University of Minnesota Supercomputing Institute for the grant of supercomputing facilities.