Competing magnetic orders and spin liquids in three-dimensional quantum magnets

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Abstract

Quantum magnetism and the formation of quantum spin liquids remains one of the most intriguing aspects of contemporary solid-state physics, which is corroborated by the high research activity of experimentalists and theorists alike. Candidate materials to host spin-liquid behavior include a variety of two-dimensional compounds, ranging from geometrically frustrated Heisenberg models to exchange-frustrated models of Kitaev type, but they also comprise three-dimensional structures. Only recently, interest was sparked by the discovery of spin liquid signatures in NiRh2O4, a three-dimensional material that realizes spin-1 moments on the diamond lattice with additional frustration mediated by next-nearest neighbor interactions. To complement experimental findings with appropriate theoretical understanding, an efficient methodological framework is vital that is capable of capturing quantum magnetism in three dimensions – a challenging regime, which is inaccessible to many conventional (both numerical and analytical) methods. In this work, we report on recent methodological advances of the pseudofermion functional renormalization group (pf-FRG), which is suited to describe three-dimensional frustrated quantum magnetism even at finite temperatures, and leverage the method to model the interplay of magnetic order, quantum order-by-disorder, and spin liquids in NiRh2O4 as well as in other materials.

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