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Title: *Classical and Quantum Spin State in Frustrated Magnetic Materials*

Abstract:

A frustrated system is one whose symmetry precludes the possibility that every pairwise interaction ("bond") in the system can be satisfied at the same time. Such systems are common in all areas of physical and biological science. In the most extreme cases, they can have a disordered ground state with "macroscopic" degeneracy; that is, one that comprises a huge number of equivalent states of the same energy. Pauling's description of the low-temperature proton disorder in water ice was perhaps the first recognition of this phenomenon and remains the paradigm. In recent years, a new class of magnetic substance has been characterized, in which the disorder of the magnetic moments at low temperatures is precisely analogous to the proton disorder in water ice. These substances, known as spin ice materials[1], are perhaps the "cleanest" examples of such highly frustrated systems yet discovered. They offer an unparalleled opportunity for the study of frustration in magnetic systems at both an experimental and a theoretical level.

Remarkably, spin ices provide one of very few experimentally realized examples of fractionalization because their elementary excitations can be regarded as magnetic monopoles and, over some temperature range, the spin ice materials are best described as liquids of these emergent charges. In the presence of quantum fluctuations, one can obtain, in principle, a quantum spin liquid descended from the classical spin ice state characterized by emergent photon-like excitations. Whereas in classical spin ices the excitations are akin to electrostatic charges, in the quantum spin liquid these charges interact through a dynamic and emergent electromagnetic field. This is the so-called *quantum spin ice* state[2].

In this talk, I will describe the essential physics of spin ice, as it is currently understood and mention the latest development in the study of such quantum spin ices and the experimental search for this state of matter among real materials.

[1] S.T. Bramwell and M.J.P. Gingras, *Science* **294**, 1495 (2001).
[2] M.J.P. Gingras and P.A. McClarty, *Rep. Prog. Phys.* **77**, 056501 (2014).