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Magnetothermodynamics of spin ice and related compounds[1]

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Geometrically magnetic frustration, which results from the competition of spin-spin interactions of magnetic ions on a regular magnetic lattice, leads to a variety of exotic low temperature states including “spin ice.” “Spin ice” refers to a magnetic state wherein the two-in/two-out spin configurations of rare earth pyrochlore compounds mimic the proton positions in the water ice, characterized by the “zero point entropy” of (R/2) ln(3/2). In this study, we examine how structural disorder affects spin dynamics and the magnetic “zero point entropy.” By diluting the “spin ice” materials with nonmagnetic ions on the rare earth sites, we have found that the entropy of the diluted species depends non-monotonically on the dilution concentration, and we explain this behavior using a generalized Pauling approximation. Nonmagnetic doping on B sites leads to only a small decrease of the “zero point entropy,” indicating the robust nature of “spin-ice.” We have also studied Dy2Ge2O7, which has the same chemical formula as “spin ice” materials and Ising-like spins but a tetragonal structure. Dy2Ge2O7 undergoes a long range antiferromagnetic ordering transition, but the spin dynamics at temperatures above the order transition is similar to that observed in the canonical “spin ice” systems, suggesting that such dynamics are generic to a broader class of Ising-like rare earth systems.

References:
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[1]In collaboration with B. G. Ueland, R. S. Freitas, D. V. West, G. C. Lau, M. L. Dahlberg, E. Morosan, J.A. Fleitman, R. J. Cava, R. Moessner, P. Schiffer, and supported by NSF.