Macroscopic Degeneracy and Exotic States in Pyrochlore Heisenberg Antiferromagnets

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It is well known that the Heisenberg model with classical spins on the highly-frustrated pyrochlore lattice has a massively degenerate ground-state manifold and does not order magnetically at any temperature if the exchange interaction is limited to between nearest-neighbor spins. This fact is not changed by the addition of magnetic field; the degeneracy survives and the magnetization process does not show any characteristic feature up to the saturation field, at any temperature. However this system is in a 'critical' state, and dramatic changes can be expected whenever a perturbation is introduced which lifts the degeneracy of the ground-state manifold. In this presentation we explore the fascinating new effects which arise in an extended Heisenberg model originally introduced to explain the metamagnetic transition seen in Cr spinel oxides, ACr_2O_4 (A=Cd, Hg). In particular, we consider the consequences of thermal fluctuations on a Heisenberg model perturbed by additional longer-range interactions (which can lead to a variety of different forms of magnetic order), and of additional biquadratic interactions (which favour states with collinear spins). Using classical Monte Carlo simulation and low-temperature expansion techniques, we uncover a range of novel phenomena as a consequence of the delicate interplay among different perturbations; a spin-liquid metamagnetic state which exhibits a 'spin pseudogap' without any long-range magnetic order, a spin-nematic state with quadrupole ordering of spins, and a fluctuation-driven metamagnetic phase.

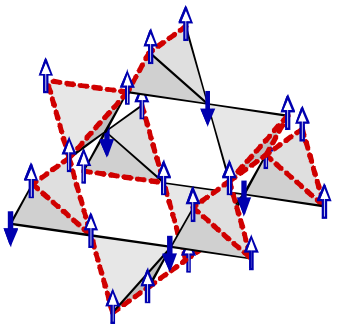

Fig: schematic picture of the spin-liquid metamagnetic state

This work has been done in collaboration with K. Penc and N. Shannon.