Physics Colloquium

Experimental signatures of a spin-liquid in a three-dimensional frustrated magnet

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Rm 118 NSH

Refreshments
in Rm 202 NSH
@ 3:30 pm

Spin-liquids are peculiar states of matter in that they do not break any symmetries of the high temperature, magnetically disordered state, but nevertheless represent a distinct phase. The spin-liquid state is defined by the emergence of excitations which carry fractional quantum numbers which can be measured directly using neutron spectroscopy. While the existence of a spin-liquid for isotropically interacting spins on the pyrochlore lattice was first speculated by Jacques Villain nearly 40 years ago, there have been no controlled experimental realizations — either classical or quantum — of this model. In real materials, the spin-liquid is more often than not preempted by small perturbations or intrinsic disorder that stabilize a broken symmetry, magnetically ordered, state. I will begin by reviewing the rich physics of frustrated magnetism on the pyrochlore lattice. Following this review, I will concentrate the discussion around a new material, $NaCaNi_2F_7$, which realizes the isotropic spin liquid of Villain but with the additional complication of random Na^+ - Ca^{2+} charge disorder in the crystal structure. I will show how neutron spectroscopy was utilized to uncover the spatial and temporal magnetic correlations in this material, fully determining the magnetic Hamiltonian. The presence of disorder creates a rugged energy landscape that acts to freeze a small fraction of the magnetic degrees of freedom in time. However, the energy scale set by this disorder is small and at higher energies the fluctuating spin-liquid phase prevails. In this case disorder actually works to stabilize the spin-liquid against additional perturbations that are present. These neutron spectroscopy measurements are the first experimental confirmation of Villain's prediction and offer a new insight into the interplay between disorder and magnetic exchange interactions in highly frustrated magnets.