Frustrated magnetic systems

Kapellasite — a cuboc2 kagome quantum spin liquid
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Inelastic neutron scattering has been used to study kapellasite, Cu3Zn(OD)6Cl2, a new geometrically frustrated spin-1/2 kagome antiferromagnet. Compared to its more well-known polymorph herbertsmithite, it has a higher degree of two-dimensionality due to a much weaker coupling between kagome planes, which in addition is unaffected by disorder. The magnetic response remains dynamic down to 20 mK with no evidence of spin freezing or long-range order. Instead, dynamic short-range spin correlations of non-coplanar cuboc2 type are observed. The magnetic excitations form a gapless continuum characteristic of fractionalized excitations. These observations classify kapellasite as a gapless kagome quantum spin liquid with competing exchange interactions.

Probing the magnetic excitations of the frustrated spinel
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Abstract unavailable

Multiferroic state in ferroaxial crystals
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Spin-driven ferroelectricity in most non-collinear magnets, such as TbMnO3, is induced by the so-called inverse Dzyaloshinskii-Moriya mechanism and requires a cycloidal magnetic structure, an ordered magnetic state that is not truly chiral (or lacks helicity). Conversely, in a truly chiral magnetic state (proper helix), the pseudo-scalar helicity can not couple directly to the electric polarization, and therefore does not induce ferroelectric order. However, in systems of specific crystal symmetry, named here “ferroaxials”, the presence of collective structural rotations mediates an indirect coupling between magnetic helicity and ferroelectricity. I will discuss new systems of this type and show from neutron scattering experiments how magnetic helicity can be controlled by an electric field.

Higgs transition from a magnetic Coulomb liquid to a ferromagnet in Yb2Ti2O7
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The emergent magnetic monopoles in a spin ice can be carried by spinons, which can undergo Bose–Einstein condensation through a first-order transition via the Higgs mechanism. Polarized neutron scattering experiments carried out on a single-crystal Yb2Ti2O7 show that the diffuse [111]-rod scattering and pinch-point features above
the transition temperature $T_s \approx 0.21$ K. Below $T_s$, magnetic Bragg peaks and a full depolarization of the neutron spins with thermal hysteresis are observed, indicating a first-order ferromagnetic transition. The results are explained on the basis of a quantum spin-ice model, whose high-temperature phase is effectively described as a magnetic Coulomb liquid, whereas the ground state shows a nearly collinear ferromagnetism with gapped spin excitation. Zero-field inelastic neutron scatterings are also employed to investigate the excitations above/below $T_s$.

**Correlations and excitations in the magnetoelastic spin-liquid state of the rare earth pyrochlore terbium titanate**

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In the rare earth pyrochlore $\text{TB}_2\text{Ti}_2\text{O}_7$, a three-fold puzzle exists - the mechanism by which $\text{TB}_2\text{Ti}_2\text{O}_7$ escapes both magnetic order and/or a structural distortion, and furthermore, the nature of the spin liquid which exists instead, are long standing questions in the field of frustrated magnetism. Recent theories propose that classical spin order is suppressed by virtual crystal field excitations which renormalize the antiferromagnetic exchange, making $\text{TB}_2\text{Ti}_2\text{O}_7$ into a type of quantum spin ice [1]; or that an undetected structural distortion leads to a spin-liquid state built of singlets [2].

Using polarized neutron scattering, we have recently shown that, at low temperature, $\text{TB}_2\text{Ti}_2\text{O}_7$ has power-law correlations, manifested by pinch point scattering, somewhat similar to a spin ice [3]. We have also discovered that an acoustic phonon is coupled to an excited crystal field state, producing a magnetoelastic mode [4]. We propose that, as in a resonating valence bond state, the existence of fluctuations stabilizes a liquid-like state in $\text{TB}_2\text{Ti}_2\text{O}_7$. In this case, the hybridization of electronic and structural excitations provides a mechanism by which both spin and structural order can be melted, such that $\text{TB}_2\text{Ti}_2\text{O}_7$ could be an analog of a quantum spin ice, with quantum tunneling fluctuations replaced by vibronic fluctuations.


**Long and short range order in the SrRe$_2$O$_4$ family of geometrically frustrated magnets**

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We use neutron diffraction as well as bulk property measurements to probe the magnetic ordering in the family of frustrated magnetic compounds, SrRe$_2$O$_4$, where the magnetic rare-earth ions are linked through a network of triangles and hexagons reminiscent of a honeycomb lattice. Among the three compounds studied, SrDy$_2$O$_4$ remains magnetically disordered down to 20 mK. SrEr$_2$O$_4$ orders magnetically at $T_N = 0.75$ K. There are two distinct components to the magnetic ordering in this compound: one component is a long-range $k = 0$ structure which appears below $T_s$, and the other component is a short-range incommensurate structure which is responsible for the appearance of a strong diffuse scattering signal. The diffuse scattering in this compound is observed to form undulating planes of intensity at the positions (h, k, $1/2 + \delta$) and (h, k, $3/2 - \delta$), with the incommensuration parameter $\delta$ varying with temperature from 0.2 to 0.6. PND data obtained on SrHo$_2$O$_4$ indicate a magnetic structure...
very similar to the one observed in SrEr₂O₄. However, more precise single-crystal neutron diffraction measurements suggest that even the k = 0 component appearing below Tₘ = 0.68 K is short-range in SrHo₂O₄. The planes of scattering intensity formed in reciprocal space by the diffuse component are not as undulated (both in their position and their intensity) as in SrEr₂O₄, which suggests that SrHo₂O₄ should be regarded as a collection of almost perfect one-dimensional spin chains. Intriguing behaviour for all three compounds is observed in applied magnetic fields.