P.056 Ice rule correlations in stuffed spin ice

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Stuffed spin ice is a chemical variation of a spin ice material like Ho₂Ti₂O₇ in which extra magnetic ions are inserted into the crystal structure. Previous studies have shown that the degree of stuffing has very little effect on the residual entropy in the system, which takes a value very close to the spin ice entropy. We argue, however, that the observation of this entropy does not imply long range coherence of the ice rules, that determine the local spin configurations. We have characterised deviations from the ice rules by means of a polarized neutron diffraction study of a single crystal of Ho₂⁺δTi₂−δO₇−δ/2 with δ = 0.3. Our results demonstrate that the ice rules in stuffed spin ice are strictly valid only over a relatively short range, and that at longer range stuffed spin ice exhibits some characteristics of a 'cluster glass', with a tendency to more conventional ferromagnetic correlations.

P.057 Studies of spin liquid candidate Nd₂Sn₂O₇

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The rare-earth pyrochlore magnets have been a productive area of research over the past 15 years including the discovery of spin ice [1], quantum spin ice [2] and magnetic coulomb phases [3]. In general the titanates have been the easiest to study due to the availability of high quality single crystals while these are not available for the rare-earth stannates. Despite this complex ground states have been shown to exist in the stannate rare-earth pyrochlores such as spin ice in Ho₂Sn₂O₇ [4] and a complex quantum frustrated state in Tb₂Sn₂O₇ [5]. We present neutron scattering, magnetic susceptibility and specific heat capacity results which fully characterise the magnetic properties of the pyrochlore Nd₂Sn₂O₇ at temperatures as low as 1.8 K. We find that no transition to a magnetically ordered state is visible in zero field down to the lowest temperatures available in this study, but that in magnetic field the Nd moments can be polarized easily. A refinement of the resultant neutron scattering pattern suggests some strong single ion anisotropy in the system.

P.058 Spin waves in honeycomb iridates and relevance of Kitaev physics
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There is increasing interest in novel Mott physics in 5d oxide induced by strong spin-orbit coupling with theoretical proposals for bond-dependent magnetic exchages in honeycomb lattices, so called Kitaev model, which may display exotic quantum spin liquid physics [1], not yet realised in a magnet. To search for such physics, we performed powder inelastic neutron scattering (INS) on honeycomb iridates A₂IrO₃ (A=Li, Na). INS is very challenging due to the extremely strong neutron absorption of Ir, but we successfully observed a clear magnetic inelastic signal with an optimised setup. In Na₂IrO₃, we observed dispersive excitations below 5 meV [2] that we compare quantitatively with spin waves of a nearest-neighbour Kitaev-Heisenberg model, as well as a Heisenberg model with up to third-neighbour exchanges. From this we deduce an unexpected pattern of zig-zag ferromagnetic chains ordered antiferromagnetically with frustration between further neighbour interactions important for its stability. To understand possible origins of departures from the ideal geometry of cubic octahedra with 90 degree Ir-O-Ir bonds when Kitaev physics is expected to dominate, we performed single crystal x-ray diffractions combined with ab initio structural relaxations and propose a revised crystal structure with important trigonal distortions of IrO₆ octahedra, significant deviations from orthogonal Ir-O-Ir bonds and stacking faults. We will also show recent results on Li₂IrO₃ and discuss similarities and differences compared to Na₂IrO₃ in terms of magnetic ordering pattern and excitation spectrum.


P.059 Spin-lattice coupling and tetragonal-to-orthorhombic distortion in ferrimagnetic spinel Mn₃O₄
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In transition metal oxides, novel phase transitions may appear when there are intimate interactions between multiple degrees of freedom, such as spin, charge, and/or orbital. Such strong couplings between spin and orbital, for instance, can often be observed in the form of large response of crystal lattice to external magnetic fields. It was recently reported that the ferrimagnetic spinel Mn₃O₄ undergoes tetragonal-to-orthorhombic transition under magnetic fields applied perpendicular to the c axis.[1] In this work using single crystal neutron diffraction, we investigated the temperature and magnetic-field dependencies of the lattice distortion in Mn₃O₄ and their relations to the magnetic ordering. In zero field, a uniform contraction of the unit cell was observed when ferrimagnetic ordering appeared at TN = 42 K, followed by a weak orthorhombic distortion near 20 K. When the magnetic field was applied along [1 0 0], the lattice underwent a large distortion [(a-b)/a₀ ~ 0.006] along the direction parallel to the field and the long-range cell-doubling order was suppressed. The onset temperature of the distortion showed significant dependence on the strength of the magnetic field between the above two temperatures. In contrast, no significant lattice distortion was observed when the field was applied along [1 1 0]. We will discuss the implications of the observed lattice distortion in relations to the strong coupling between spin and orbital degrees of freedom.

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P.060 Magnetic frustration in the Lu$_2$Mo$_2$O$_7$ and Lu$_2$Mo$_2$O$_5$N$_2$ pyrochlores

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The ground state magnetic properties of the rare earth molybdate pyrochlores, R$_2$Mo$_2$O$_7$, are known to depend strongly upon lattice effects, such as the ionic radius of rare earth cation. Y$_2$Mo$_2$O$_7$ is a well-studied example of a spin glass-like material in this series; however, the origin of this behaviour is still not completely understood. We have prepared polycrystalline samples of the related S = 1 pyrochlore Lu$_2$Mo$_2$O$_7$ for which we present neutron scattering data collected at the Institut Laue-Langevin. We discuss the presence of a miscibility gap between two coexisting pyrochlore phases, stoichiometric Lu$_2$Mo$_2$O$_7$ and oxygen deficient Lu$_2$Mo$_2$O$_{6.6}$, which was revealed through analysis of powder neutron diffraction data collected on the D2B instrument and demonstrate the absence of long range magnetic order from low temperature powder neutron diffraction data (D2B) and magnetic diffuse scattering data (D7). We show evidence for the formation of a frustrated spin glass-like ground state at a spin freezing transition ~ 20 K in the Lu$_2$Mo$_2$O$_{7-x}$ system which is sensitive to oxygen content. Ammonolysis of R$_2$Mo$_2$O$_7$ gives oxynitride pyrochlores with a limiting composition R$_2$Mo$_2$O$_5$N$_2$, which have Mo$^{5+}$ S = ½ cations situated on the frustrated pyrochlore lattice and are thus excellent candidate materials for the study of quantum spin liquid phenomena. We have synthesised a new oxynitride pyrochlore Lu$_2$Mo$_2$O$_5$N$_2$ for which we present magnetic susceptibility and powder neutron diffraction data (D2B) that show no evidence for spin freezing or long range magnetic order upon cooling despite significant antiferromagnetic exchange interactions.


P.061 Unearthing the true phase diagram of the frustrated hyperkagome Gd$_3$Ga$_5$O$_{12}$

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Gd$_3$Ga$_5$O$_{12}$ (GGG) is the archetypal frustrated compound with a hyperkagome structure of interconnected triangles of Gd ions. Frustration prevents GGG from ordering down to 25 mK despite a Curie Weiss temperature of -2.8 K. The (H,T) phase diagram has long been understood in terms of distinct regions with short range order below 800 mK (0 T) supplemented with distinct clustered regions of incommensurate (IC) correlations below 0.14 K [2]. According to this phase diagram the application of only 0.7 T (60 mK) results in a stable antiferromagnetic (AF) region up to 1.2 T (60 mK) that extends out to 400 mK (1 T). Recent polarised neutron diffraction could not be reconciled with this phase diagram. The distinct regions of bear no comparison to the smooth and subtle variation in scattering profiles with applied magnetic field. To understand the scattering features, magnetic susceptibility measurements were performed on powder and single crystal samples to redefine the phase diagram. It appears that the phase diagram is much more complicated than previously realised and can be understood in terms of the competing interactions with loops of spins, from triangular to decagons, in addition to competition between AF, FM and IC order [3]. These results correlate the large dynamic range observed previously, from pico to meV dynamics [4,5], to the zero energy modes of loops of spins, thus endorsing a fundamental prediction for the kagome lattice [6].

P.062 Spin correlations and excitations in the quasi-2D triangular bilayer spin glass LuCoGaO₄
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LuCoGaO₄ is a layered magnetic-bilayer material wherein Co²⁺ magnetic moments and nonmagnetic Ga³⁺ ions are randomly distributed on planar triangular bilayers in a hexagonal crystal structure. This makes it an ideal case to study the interplay between geometric frustration, site disorder and low dimensionality and its influence on the magnetic ground of the system. This novel material has been grown for the first time in single crystal form at McMaster University. We have performed magnetization measurements, which show the previously identified spin glass transition near Tg~19K, and a Curie Weiss temperature of Tcw~96K, consistent with antiferromagnetic interactions[1]. We discuss time-of-flight neutron scattering measurements using SEQUOIA and CNCS at SNS which elucidate the evolution of the static and dynamic spin correlations in LuCoGaO4 over a range of temperatures from T<< Tg to T>Tcw. We observe quasielastic scattering at (1/3,1/3,L) positions in reciprocal space and rods of scattering along the c*-direction, consistent with short range antiferromagnetic correlations within decoupled bilayers, and which confirm the 2-dimensional character of this system. Inelastic scattering measurements show a resonant gapped ~ 12 meV spin excitation which softens and broadens in energy, filling in the gap on a temperature scale of ~ Tcw/2.


P.063 Ho₂Ge₂O₇ and Pr₂Zr₂O₇: A tale of two spin ice
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The spin ice state is a rare magnetic ground state that can be observed in the pyrochlore oxides, A₂B₂O₇. In this short-range ordered state, the spins, which are arranged in a corner-sharing tetrahedral motif, align such that two spins point inwards and two outwards on each tetrahedron. The emergence of monopole-like excitations in spin ices has given rise to immense interest in this class of materials. However, a complex set of conditions must be met in order for a material to adopt the spin ice state, making them exceedingly rare. Prior theoretical studies have put forth two pyrochlores, Ho₂Ge₂O₇ and Pr₂Zr₂O₇, as spin ice candidates. The aim of this project was to fully characterize these compounds and determine their magnetic ground states. We show through physical property measurements, polarized neutron scattering, and inelastic neutron scattering experiments that Ho₂Ge₂O₇ is a new, highly correlated spin ice material. Conversely, Pr₂Zr₂O₇, while exhibiting many spin ice properties, has a non-magnetic, singlet ground state.
P.064 The "ice-rule" and magnetization in the inverse opal-like structure

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The evolution of the magnetic structure under an applied magnetic field is studied for an inverse opal-like structure (IOLS). The samples were produced by the filling of the voids of an artificial opal film with Co. Small-angle neutron scattering (SANS) technique is used to detect changes in the local magnetization, which is inhomogeneously distributed over the basic element of the IOLS but follows its periodicity. We used the "ice-rule" concept to describe the local magnetization of this ferromagnetic three-dimensional lattice. We have created a model of the remagnetization process predicting the appearance of an unusual perpendicular component of the magnetization in the IOLS determined only by the direction and strength of the applied magnetic field.

P.065 Domain growth kinetics in field-induced threefold-degenerate ferrimagnetic phase of the isosceles triangular Ising antiferromagnet CoNb$_2$O$_6$

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We have studied the domain-growth kinetics of field-induced threefold-degenerate ferrimagnetic states in the isosceles triangular Ising antiferromagnet CoNb$_2$O$_6$ by measuring the time evolution of the scattering profile along the b* direction in the transverse scan at (3,1/3,0) magnetic Bragg point in the time range up to 2*10$^4$ sec. The results are consistent with the power-growth law having an universal growth exponent $n \approx 0.2$ suggested in our previous ac-susceptibility and Monte Carlo simulation study on CoNb$_2$O$_6$ [S. Kobayashi et al. Phys. Rev. B 69, 144430 (2004)], where embedded A'C'-type domain wall is considered to move almost freely at specific magnetic field $H \approx 1300$ Oe.

P.066 Real-time observation of magnetic structural change in frustrated magnets

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Long-time variations of magnetic properties observed in spin-glasses have been regarded as due to the multi-valley structure of the free energy surface arising from random magnetic interactions. Therefore, in a system without randomness or imperfections we have not expected to observe a time variation of magnetic property within an attainable time scale. Contrary to all expectations, we found a long-time variation of magnetic structure in a non-diluted uniform magnet CeIr$_3$Si$_2$ by means of time-resolved neutron scattering measurements.[1,2] We examined other materials and have found similar long-time variations of magnetic structure in PrCo$_2$Si$_2$, TbNi$_2$Si$_2$, Ca$_3$Co$_2$O$_6$ and some other compounds.[3,4]

All these compounds exhibit successive magnetic transitions and multi-step metamagnetic transitions, which suggest that the frustrations coming from competing magnetic interactions causes the long-time variation of magnetic structure. In order to show that randomness caused by inevitable impurities or imperfections is not the main cause of the long-time variation, we have made macroscopic and neutron scattering measurements of a random system (Ce-La)Ir$_5$Si$_2$ and Ca$_4$(Co-M)$_2$O$_6$ systems. The time variation behavior of these random systems is basically identical to that of mother compounds. These results have shown that the long-time variation of magnetic structure in these materials does not originate in randomness.

P.067 Impurity effects on long-time variation of magnetic structure in frustrated magnet Ca$_3$Co$_2$O$_6$

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We have reported that CeIr$_3$Si$_2$, Ca$_3$Co$_2$O$_6$ and some other materials show long-time variation of magnetic structure [1-4]. These materials are uniform compounds including neither appreciable randomness nor imperfections. All of these compounds show successive magnetic transitions and metamagnetic transitions at low magnetic field, which indicate the presence of competing magnetic interactions. Therefore, we think that the long-time variation of magnetic structure in these materials is caused by the competing magnetic interactions. To ensure that neither the randomness nor imperfections is the main factor causing the long-time variation of magnetic structure, we have investigated the doping effects.

In this presentation, we show the time variation of neutron scattering patterns of Ca$_3$Co$_2$O$_6$ and Ca$_3$(Co$_{1-x}$M$_x$)$_2$O$_6$. The time variations of the pattern were measured after the sample was cooled to various target temperatures from $T=30$ K ($T>T_{c1}$). Characteristics of the time variation behavior were not much modified by the disorder produced by the substitution of non-magnetic elements. The time variation of the magnetization of Ca$_3$(Co$_{1-x}$M$_x$)$_2$O$_6$ (M=Mg and Ga) is also basically same to that of Ca$_3$Co$_2$O$_6$. These results show that the long-time variation of the magnetic structure in Ca$_3$Co$_2$O$_6$ is not caused by randomness nor imperfections.


P.068 Excitations under fields of the pinwheel valence bond solid state in the Kagomé antiferromagnet Rb$_2$Cu$_3$SnF$_{12}$

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Geometrically frustrated magnets have attracted considerable interest. Among such magnets with spatial dimensions of two, Kagomé lattice antiferromagnets (KAFs) have been intensively studied as one of the most highly frustrated systems. Given the low number of connectivity being comprised of corner-sharing triangles, the KAF is considered as a prime candidate to search for possible realization of theoretically predicted quantum spin states, such as resonating valence bond (RVB) and valence bond solid (VBS) states.

Our recent work provides the first evidence of so-called 'pinwheel' VBS state in the KAF Rb$_2$Cu$_3$SnF$_{12}$ [1]. The pinwheel VBS is stabilized by the lattice distortion that gives rise to a spatially non-uniform distribution of four different nearest-neighbor interactions. Through inelastic neutron scattering experiments using triple-axis and chopper spectrometers, we observed the spin-1 singlet to triplet excitations. The degeneracy of the triplet states is lifted into a non-degenerate $S_z = 0$ and two-fold degenerate $S_z = \pm 1$ states by the Dzyaloshinskii-Moriya (DM) interaction.
With applying a magnetic field perpendicular to the Kagomé plane, the $S_z = -1$ excitation is revealed to deviate from linear decrease against fields and finally persists near 1 meV for fields between 9 T and 15.5 T. It suggests important roles of DM interactions and/or tilted g-tensor due to CuF₆ octahedra arrangement in this material, leading staggered fields that induce another gap. Our experimental findings and exact diagonalization calculation that accounts for the results will be presented.


P.069 Spin correlations in frustrated magnets from powder neutron scattering

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Frustrated magnetism plays a central role in our understanding of exotic states of condensed matter. However, since the magnetic structures of frustrated systems are often aperiodic, there has been the problem that they cannot be determined by using traditional crystallographic methods. In this talk, I will explore the information content of the magnetic powder diffuse scattering pattern of frustrated magnets. I will address how these data can be converted robustly into a model of the spin correlations, without any prior knowledge of the underlying magnetic interactions. Our approach is to consider simulated powder data for a number of test cases. These data are then fitted using the atomistic reverse Monte Carlo (RMC) method. Finally, the quality of the models obtained is assessed by calculating the full single-crystal magnetic scattering pattern. I will show that the extent of information loss during powder averaging of the magnetic scattering is surprisingly minimal, and that the full 3D scattering pattern is recoverable from powder data for each frustrated system that we explore.

I will go on to discuss two real examples where we have used this approach to obtain insight into frustrated materials. First, I will consider the evolution with temperature of ice-rules defects in the newly-synthesized spin ice material, Ho₀Ge₂O₇. Second, I will examine the interplay between geometrical frustration and low dimensionality in the paramagnetic phase of the spin-chain compound Ca₃Co₂O₆. Finally, I will discuss how the RMC method can be extended for the analysis of the three-dimensional diffuse scattering patterns now obtainable using single crystal samples.

P.070 Spin dynamics in the highly frustrated kagomé system CaBaCo₂Fe₂O₇

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Recent studies of spin correlations in new materials belonging to the swedenborgite compound family (∑₆/₃mc)[1] exhibit various signs of unusual strong geometric frustration: at low temperatures, indications for quasi 2D spin correlations, spin glass or spin liquid states and rather complex, partly ordered ground states have been observed.[2-5]

In compounds with the magnetic Co and Fe ions, where single crystals are available like the CaBaCo₂Fe₂O₇, we observed an antiferromagnetic ordering below $T_N = 160$ K, which, however, turned out to be rather complex. Its broken inversion symmetry raises further the complexity of ordering due to non-vanishing Dzyaloshinskii-Moriya interactions. Diffuse neutron scattering measurements have shown that the magnetic spins order in a $\sqrt{3} \times \sqrt{3}$ supercell. A particular intriguing result was chiral interference observed apparently as an asymmetry of the magnetic Bragg intensities (DNS, MORPHEUS).
Since the material characteristics are dominated by the strong magnetic frustration, excitations are very sensitive to small changes in ordering and exchange interactions. We will present neutron inelastic scattering on a single crystal, obtained from triple axis (PANDA) and thermal time-of-flight scattering (ARCS). The experimental results will be discussed in comparison with linear spin wave theory calculations based on nearest neighbor Heisenberg model.


P.071 Effect on magnetic and structural properties of doping layered Iridates \( \text{A}_2\text{IrO}_3 \)

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Recently, 5d transition metal compounds promoted interest due to their strongly correlated physics. The interplay of the relativistic spin-orbit coupling, local multiplet physics, crystal-field effects, and inter-site hopping offers novel types of correlated ground states and excitations. Promising compounds with a spin liquid ground state also shall be found within the Iridates. Doping a spin liquid is suggested to create new phases, such as high Tc superconductivity in cuprates. To find the parent spin liquid, quantum frustrated Mott insulators, as certain Iridium oxide compounds were brought into focus. An exactly solvable spin model with the spin liquid ground state was proposed by Kitaev on honeycomb lattice [1] and later has become potentially realizable in \( \text{A}_2\text{IrO}_3 \) (A=Na,Li) layered iridates [2]. A light doping of \( \text{A}_2\text{IrO}_3 \) is for example suggested to lead to a spin triplet topological superconductor [4]. It is proposed, that these materials contain the necessary anisotropic exchange interactions [3] and that the spin liquid ground state resists the small but always present isotropic exchange. We will present here the influence of doping of these layered iridates with silver and lanthanum as well as hole doping on their structural and magnetic properties.


P.072 Excitation spectrum of \( \text{Tb}_2\text{Ti}_2\text{O}_7 \) investigated by neutron scattering

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The frustrated magnet \( \text{Tb}_2\text{Ti}_2\text{O}_7 \) is a rare earth pyrochlore with antiferromagnetically coupled, anisotropic magnetic moments, so that classical spins should be unfrustrated and order at T~1 K. However, no ordering is observed down to 0.05 K, motivating theories that incorporate quantum fluctuations and describe \( \text{Tb}_2\text{Ti}_2\text{O}_7 \) as “quantum spin ice” [1]. Similarly, the absence of a structural phase transition is a puzzle [2]. Because Tb\(^{3+}\) is a non-Kramers ion, the doublet ground state is susceptible to a Jahn-Teller transition. Instead, the low temperature state of \( \text{Tb}_2\text{Ti}_2\text{O}_7 \) appears to be a spin liquid with algebraic spin correlations [3], and strong magnetoelastic effects [4].

In this poster we present progress in our research on \( \text{Tb}_2\text{Ti}_2\text{O}_7 \). Using neutron scattering we have discovered a magnetoelastic mode, which disappears above 20 K. A detailed understanding of the excitation spectrum requires knowledge of the lattice dynamics of \( \text{Tb}_2\text{Ti}_2\text{O}_7 \). Hence, we have started to study the phonon spectrum of \( \text{Tb}_2\text{Ti}_2\text{O}_7 \).
using the new thermal triple axis spectrometer EIGER at PSI, and performing ab-initio calculations. Furthermore, we present high-resolution neutron time-of-flight data of Tb₂Ti₂O₇ in the low-temperature regime that indicates a quasielastic contribution to the elastic line, rather than a splitting.


P.073 The effect of impurities on the structure and magnetism in spin ice crystals

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Spin ice crystals (and pyrochlore oxides in general) have raised a lot of interest of late thanks to their exotic properties, including emergent gauge symmetries, possible spin liquid behavior, and magnetic monopole excitations. Theoretical and experimental efforts in the study of these materials have benefited from the relative ease of growth of large clean single crystals. Even in such clean systems, however, impurities can play a crucial role in determining the properties at very low temperatures (see e.g., C. Henley, http://arxiv.org/abs/1210.8137). Here we investigate this issue both experimentally and theoretically. We study how controlled non-magnetic Y-dilution in Dy₂Ti₂O₇ gradually alters the effective monopole description and the thermodynamic properties of the system at low temperature (extending earlier work by other authors to regimes that have not been investigated so far). We also study how oxygen deficiency affects spin ice samples, and we discuss how the oxygen stoichiometry can be quantified and controlled experimentally.

P.074 Field-induced magnetic structure of Tb₂Ti₂O₇ spin liquid for \( H || [111] \) at very low temperatures

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Tb₂Ti₂O₇ spin liquid has a zero-field ground state akin to a cooperative paramagnet where strongly correlated magnetic moments fluctuate down to 50mK [Gardner et al, PRL 82, 1012 (1999)]. The exact reason why it behaves as a spin liquid is still a matter of debate. It was suggested that, unlike spin ices, the crystal field scheme allows the admixture of excited crystal field levels into the ground state doublet, leading the word "quantum spin ice" [Molavian et al, PRL 98, 157204 (2007)]. Alternatively, we proposed a symmetry breaking as the source of the magnetic fluctuations in the ground state, yielding a two singlet ground state for the Tb ion [Bonville et al, PRB 84, 184409 (2011); Petit et al., PRB 86, 174403 (2012)].

A way to investigate the ground state is to perturb it by a field \( H \), which induces long-range magnetic order in Tb₂Ti₂O₇. For \( H || [111] \) the quantum spin-ice model predicts a magnetization plateau [Molavian and Gingras, J. Phys.: Cond. Mat. 21, 172201 (2009)], which was not observed [Lhotel et al, PRB 86, 020410 (2012); Legl et al., PRL 109, 047201 (2012)].

Here, we have determined the magnetic structure of Tb₂Ti₂O₇ for \( H || [111] \) using single-crystal neutron diffraction and symmetry analysis. The experiment was done on D23 diffractometer at the Institute Laue-Langevin up to a field of 12T and down to 50mK. We found an irreducible representation which describes the experimental data very well and agrees with the magnetization measurements. The field variations of the magnetic moments and angles were also compared to the mean-field calculations. The results discard the possibility of a magnetization plateau and strongly support the presence of a distortion, which persists in applied field.
P.075 Novel liquid-like excitations in single crystalline $Y_2Mo_2O_7$: an unconventional spin glass

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For nearly three decades, $Y_2Mo_2O_7$ has been the source of considerable debate in the materials science community. Adopting the pyrochlore structure, $Y_2Mo_2O_7$ can be described as interpenetrating tetrahedral networks containing either $Y^{3+}$ or $Mo^{4+}$ ions at the vertices. $Y_2Mo_2O_7$ ($\Theta_{CW}=200$ K) undergoes a spin glass transition at $T_g=22.5$ K despite showing no signs of chemical disorder such as site mixing or nonstoichiometry, which is thought to be a prerequisite for such behavior. In this study, we have succeeded in growing, to our knowledge, the world’s first large single crystal of this material. Here, we present rare isotropic ring-like diffuse scattering features using neutron diffraction despite having a well-ordered and high-quality crystal. Coupled with magnetic susceptibility measurements, heat capacity measurements, and theoretical modeling, it is shown that orbital effects might play a significant role in describing the glassy behavior.

P.076 Interplay of lattice, spin and orbital effects in the Mott insulator LuVO$_3$

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Transition metal oxides play a central role in condensed matter physics, and in the particular case of LuVO$_3$ this is due to lattice, spin and orbital degrees of freedom with similar energy scales. These degeneracies can lead to very interesting phases, for instance combined spin-orbital ordering, orbital-Peierls states [1] and orbital fluctuations [2]. In the presently studied compound, the weak Jahn-Teller interaction gives rise to an intrinsic frustration between spin and orbital sectors. This is indirectly evidenced by the closeness of the orbital and spin transition temperatures. High-resolution powder x-ray diffraction was employed in order to clarify important details of the crystal structure. The magnetic structure was studied using polarized neutrons, in order to separate the magnetic from the nuclear part for this k=0 antiferromagnet. Further to this, resonant x-rays were used to probe the orbital degrees of freedom, modeled by the ab-initio FDMNES code [3]. Three distinct phases were found for the combined spin-orbital system (G- and C-type combinations), out of which two are magnetic. The spin waves in both magnetic phases show a strikingly different behaviour, and spin-wave modeling enables us to construct corresponding Hamiltonians which are based on microscopic models involving orbital-overlaps [4].

P.077 Antiferromagnetic Heisenberg spins on a pyrochlore lattice. Should be simple - right?

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The compounds Gd₃Sn₂O₇ (GSO) and Gd₃Ti₂O₇ (GTO) are examples of a Heisenberg antiferromagnet on a pyrochlore lattice, with an L=0 Gd³⁺ ion exhibiting minimal single-ion anisotropy. Below 1K, these compounds exhibit different antiferromagnetic orderings, with GTO exhibiting a complex multi-k structure [1], while GSO orders in the Palmer-Chalker k = 0 ground-state [2]. Application of a magnetic field to both GTO and GSO reveals a rich phase diagram for fields < 6T. Magnetisation and ac-susceptibility measurements reveal the existence of multiple phase transitions in both GSO and GTO below 1 K. [3,4]

Using the WISH diffractometer at ISIS we have performed neutron powder diffraction in a magnetic field on GSO with an isotopic enrichment of > 99.8% 160Gd to mitigate against neutron absorption. We identify around 5 magnetic transitions at 70 mK as a function of field, with full FM moment saturation occurring only at fields > 10 T. Most interestingly, while in the high field phase, the full moment of 7 μB is recovered from the data, at zero field in the Palmer-Chalker state, only half the full Gd moment is found in the ordered state, co-existing with a significant disordered fraction.


P.078 Pressure-dependent spin fluctuations and magnetic structure in the topologically frustrated spin glass alloy Y(Mn₀.₉₅Al₀.₀₅)₂

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Longitudinal field (LF = 110 G) muon spin relaxation (μSR) has been used to investigate the pressure dependence (P < 4.5 kbar) of paramagnetic spin fluctuations in the spin glass alloy Y(Mn₀.₉₅Al₀.₀₅)₂ via observation of the μ⁺ spin depolarization. External mechanical force is seen to counteract the Al-induced chemical pressure, fully delocalizing the Mn moment and altering the nature of the spin fluctuation spectrum sensed by the muon. A qualitative change in the functional form of the μ⁺ spin depolarization is observed. Complementary ambient and high-pressure neutron diffraction measurements suggest not only pressure-dependent structural transitions but also the instability of the localized manganese moment. The ambient and high-pressure μ⁺ spin depolarization results from Y(Mn₀.₉₅Al₀.₀₅)₂ are likened to P = 0 results reported for other Y(MnₓAl₁₋ₓ)₂ alloys. Finally, the possibility of using μ⁺ spin depolarization rates to predict experimental inelastic neutron scattering (INS) line widths is considered; the muon having the potential to provide information equivalent to that obtained via INS but with greatly reduced data collection times.

P.079 Rare-earth substitution in Ca₂Co₂O₆ : stabilization of the spin density wave structure

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Due to a large ground state degeneracy in geometrically frustrated triangular lattice Ising antiferromagnets, such as Ca₂Co₂O₆, discovering the stable magnetic ground state of such frustrated magnets in the presence of a perturbation is of current interest. To address the issue of the stability and the nature of magnetic ground state in Ca₂Co₂O₆ based system, we have investigated Ca₂₋ₓRxCo₂O₆ (R = Lu and Dy) by neutron diffraction. We have chosen Lu and Dy substitution because of a significant difference in the ionic radii of Lu³⁺ (0.977 Å) and Dy³⁺ (1.027 Å). The
magnetic structure corresponds to a spin density wave (SDW) with a propagation vector \( \mathbf{k} = \{0, 0, 1.02\} \), having \( c \) axis as direction of both moment and modulation. For both compounds, the refined values of the ordered moment at the 18e, 6b, and 6a sites are 0.04(2), 0.03(2), and 4.2(2) \( \mu_B \), respectively. Unlike the parent compound \( \text{Ca}_3\text{Co}_2\text{O}_6 \), neither a second set of antiferromagnetic (AFM) Bragg peaks corresponding to a commensurate AFM structure with a propagation vector \( \mathbf{k}_2 = \{0.5, 0.5, 0\} \), nor a time dependence in the Bragg intensity of the SDW structure has been observed down to 1.5K. This confirms that the SDW structure is stabilized (with a decrease in Neel temperature) by the substitution with R-ions. This has been explained due to a decrease in the value of positive intrachain exchange interaction, consistent with our observation of an increase in the lattice constant \( a \), with the substitution by the R-ions. The stabilization of the SDW structure with reduced strength of the positive intrachain interaction is consistent with the theoretical results for the parent compound \( \text{Ca}_3\text{Co}_2\text{O}_6 \) [Chapon, Phys. Rev. B80 (2009) 172405].