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Studies of the Geometrically-Frustrated Pyrochlore Antiferromagnets $Y_2Mo_2O_7$ and $Tb_2Ti_2O_7$

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Introduction

The oxide pyrochlore family, with chemical composition $A_2B_2O_7$, crystallises into a face centred cubic structure with eight formula units per conventional unit cell [1]. The metal atoms A and B form two infinite chains of corner sharing tetrahedra and if either the A or B atoms is magnetic with an antiferromagnetic nearest neighbour interaction, then there is a high degree of frustration within the lattice.

In the last 10 years there has been several studied on the pyrochlore systems [1-3], attempting to describe their physical properties and explaining their unusual behaviour. One such characteristic of many of the magnetically frustrated pyrochlores is that they show a classic spin-glass behaviour in the history dependence of the magnetic susceptibility. This is unexpected however, since it is generally assumed, that a spin glass is a result of chemical disorder and all diffraction studies to date on the pyrochlore systems have found them to be ordered (at least to below the 1% level) [3].

Neutron studies were carried out on the high resolution powder diffractometer, of the NRU reactor at Chalk River Laboratories, with an incident neutron wavelength of 2.37Å and 4Å. The eighty degree detector bank was moved between two positions in order to obtain data from 3° to 115° in two theta. D. c. susceptibility measurements were carried out between 2K and room temperature in a high field Quantum Design SQUID magnetometer.

Here we will report our findings of studies of polycrystalline $Tb_2Ti_2O_7$ and $Y_2Mo_2O_7$ at temperatures down to 2.5K in order to investigate the build-up of magnetic correlations in these magnetically frustrated systems. In these two compounds, where either the A or B-site is magnetic, several distinct differences have been seen.

Results and Discussion

The magnetic susceptibility of $Tb_2Ti_2O_7$ follows the Curie-Wiess law with a calculated effective magnetic moment of 9.4 μ_B (cf. 9.6 μ_B for the free moment). The paramagnetic Curie temperature, also calculated from the high temperature fit, was found to be -2.2K.

$Y_2Mo_2O_7$ shows a typical spin-glass-like cusp in it's susceptibility, with a spin freezing temperature T_f of 25K. No cusp or magnetic history dependence was observed in the $Tb_2Ti_2O_7$ sample down to 2K.

The static spin correlations observed in $Tb_2Ti_2O_7$ are very liquid-like down to the lowest temperatures studied. Broad bumps at **Q** $\approx$1.1Å $^{-1}$ and 3Å $^{-1}$ are observed in neutron diffraction patterns below 100K. This is evidence of short range correlations in $Tb_2Ti_2O_7$ although magnetic susceptibility results are paramagnetic-like. No observation of short range correlations have been seen in similar neutron experiments on $Y_2Mo_2O_7$.

Figure 1 shows the results of subtracting high temperature diffraction data of $Tb_2Ti_2O_7$ (100K) from 50, 15 and 2.5K data sets plotted against the wave-vector, **Q**. The inset is the d.c. susceptibility of $Tb_2Ti_2O_7$.

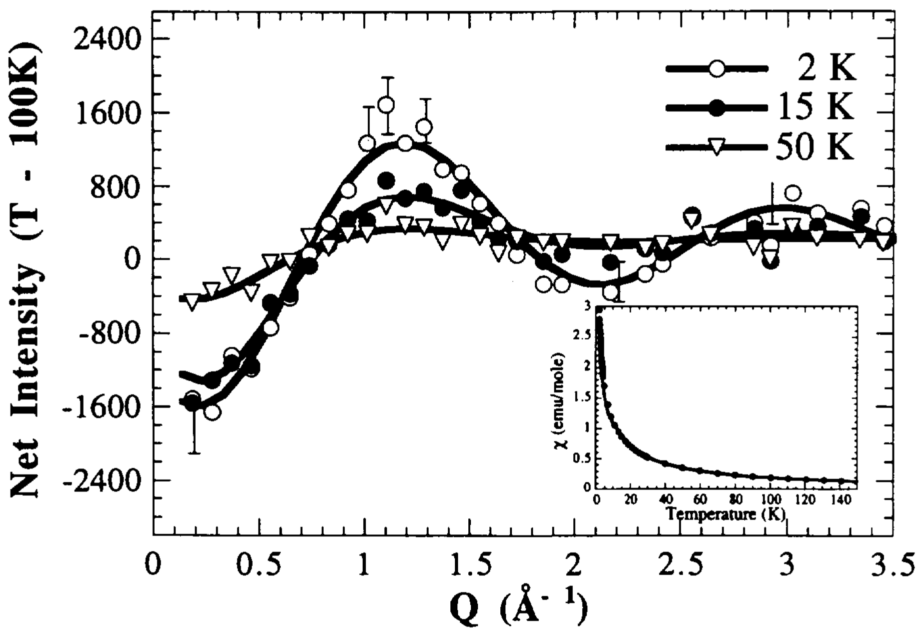

Figure 1. The diffuse scattering from $Tb_2Ti_2O_7$ at 2,15 and 50 K. The inset shows its susceptibility which is very Currie-Wiess like.

References

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