Steacie Institute for Molecular Sciences

Neutron Program for Materials Research

Magnetic Structures

Geometric Frustration

Quantum fluctuations

NEUTRON FACT SHEET #5

Magnetism Fact Sheet

The application of neutron scattering techniques to the study of condensed matter has resulted in immense gains in our understanding of cooperative phenomena. Magnetic materials, by virtue of their relative simplicity and the short-range nature of magnetic interactions, have served as prototypical cooperative systems.
The magnetism and superconductivity program provides users with a variety of environments (see list below) in which their sample can be mounted while performing elastic and/or inelastic neutron scattering measurements. The range of wavelength and energy possessed by thermally moderated neutrons allows us to study not only the nuclear long-range, static, nature of solids but also the dynamics (phonons). Similarly, the neutron's magnetic moment (S=1/2) allows it to couple well to the magnetism in solids, allowing unparalleled scrutiny of both the magnetic structure (short- and long-range) and the excitations (magnons) of magnetic materials. Neutron scattering techniques are presently considered as the most powerful probe of magnetic materials.

Figure 1: The 7 Tesla vertical and 2.5T horizontal field magnets. Both pieces of equipment can be mounted on our triple axis spectrometers.

The field of magnetism and superconductivity has not only produced some of the most exciting pieces of neutron scattering work (determination of antiferromagnetic structures (Shull and Wollan), spin dynamics in High T_c (Rossat-Mignod), etc.) but it has also advanced the development of neutron scattering techniques, such as the triple-axis spectrometer (Brockhouse), polarisation analysis (Moon, Riste and Koehler) and Neutron Spin Echo (Mezei). At the NRU, the magnetism program utilises the two triple axis spectrometers (N5 and C5) and the high resolution diffractometer (C2). C5 has the capability of performing polarised experiments and with its velocity selector we have a tunable filter for neutrons between 2.37 and 4 Å.

Current ancillary equipment allows us to apply magnetic fields up to 2.5 T in the scattering plane and 7 T perpendicular to the plane. We can reach 1.8 K in the horizontal field magnet and our bath cryostat and we have several closed cycle refrigerators.

For experiments above room temperature we have several furnaces one of which can reach 2000°C.

In-house Research

In collaboration with scientists from the United Kingdom and the United States we are studying the excitations in low dimensional quantum antiferromagnets. Detailed studies of the excitations in one dimensional spin systems such as NENP, $CsNiCl_3$ and $CsCoBr_3$ are helping to clear up several questions that recent theories have introduced to the field.

In a large collaboration with many Canadian scientists (TRIUMF, McMaster, Waterloo and Toronto) we have studied the effect of geometric frustration on magnetic systems. Unusual groundstates are brought about by the inability of these systems to uniquely minimise their energy. Neutron scattering, µSR, low temperature bulk properties and NMR experiments are allowing us to investigate the true nature of these magnetic systems. Several detailed studies on $Tb_2Ti_2O_7$ [see Phys. Rev. Lett., 82, 1012 (1999)] and $Y_2Mo_2O_7$ [see Phys. Rev. Lett., 83, 211 (1999)] were performed within the past year. Neutron scattering experiments have shown that although $Tb_2Ti_2O_7$ has a

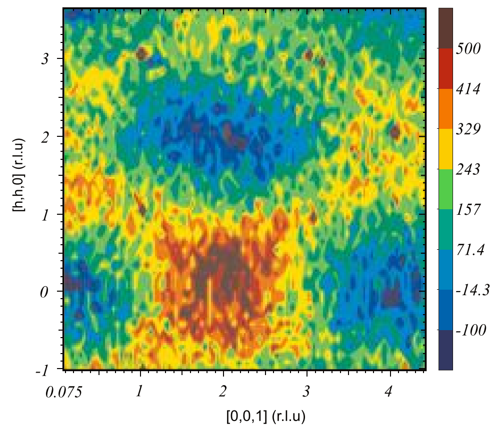

Figure 2: Diffuse magnetic scattering from the geometrically frustrated antiferromagnet, $Tb_2Ti_2O_7$, at 10 K. A nuclear component has been subtracted.

Curie-Weiss temperature of -20 K, the 9.4 µB spins on the Tb ion are still fluctuating and are only spatially correlated over nearest neighbours at 10 K, see figure 2.

User Program

Apart from our in house collaborations we also perform experiments where the visiting researcher is the driving force of a project. Two such projects are the study of the many magnetic phases of elemental holmium and the materials that exhibit colossal magneto-resistance. In these materials the competition between charge, lattice and spin degrees of freedom in these materials have led to very interesting transport and magnetic properties. The magnetic structure and temperature dependence of these materials have been investigated on C2.

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