Field-induced Magnetic Order in the Spin-liquid Kagomé $Nd_3Ga_5SiO_{14}$

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Introduction

Spins on a kagomé lattice (corner-sharing triangles) remain a celebrated example of strongly geometrically frustrated magnetism in two dimensions. These systems have received an increasing amount of attention over the last few decades due to the novel physics they offer. In particular, unusual spin liquid states composed of fluctuating strongly interacting spins at low temperatures have been predicted in these lattices. Unfortunately, previous searches for these spin liquid states have been plagued with issues of disorder upon the chemical lattice, such as in the case of the kagomé materials SCGO ($SrCr_{12-x}Ga_xO_{19}$) [1] or the jarosite $KFe_3(OH)_6(SO_4)_2$ [2]. The discovery of the new material $Nd_3Ga_5SiO_{14}$, which has very little chemical disorder, has renewed hope for the identification of a true spin liquid in two dimensions stabilized through frustrated interactions [3].

Results and Discussion

Crystals of $Nd_3Ga_5SiO_{14}$ were grown using the new image furnace of the Quantum Materials Laboratory at the NHMFL. It was discovered that there is no discernable phase transition down to 35 mK through torque magnetization measurements. This has been verified through detailed neutron scattering measurements using the Disk Chopper Spectrometer (DCS) at NIST – no magnetic Bragg peaks are observed. However, there is a substantial amount of magnetic diffuse scattering at low temperatures due to short ranged ordered fluctuating spins. This is strong evidence for a spin-liquid ground state. Upon the application of a field in the c-direction, the diffuse scattering is reduced in intensity while the magnetic Bragg peaks grow in intensity to saturate by 1 T to ½ of the expected magnetization. This partially ordered phase is still under investigation. Current models suggest that a 1/3 magnetization plateau is stabilized in high fields, but the observation of a ½ magnetization plateau is a signature of a new partially ordered magnetic state that coexists with the spin liquid (perhaps as a "polarized" spin liquid or an exotic nematic phase). These measurements suggest that a unique spin-liquid state develops in $Nd_3Ga_5SiO_{14}$ with a frustration index of $f \sim |\theta|/T_C \sim 1300$ [3].

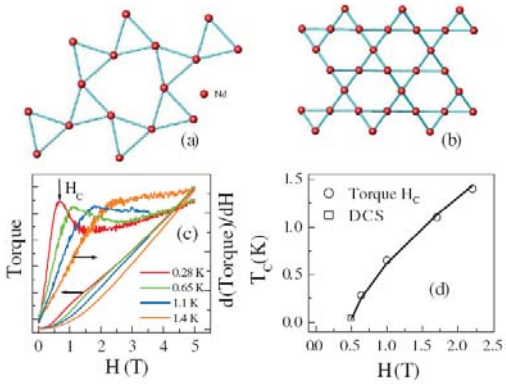

Fig. 1 (a) Kagomé lattice of $Nd_3Ga_5SiO_{14}$ (b) A "perfect" kagomé lattice (c) Torque magnetometry measurements on $Nd_3Ga_5SiO_{14}$, showing an ordering in applied fields (d) Phase diagram from torque magnetometry and neutron scattering (DCS) experiments [3]. Note the lack of magnetic order in zero field.

Conclusions

The spin liquid nature of the kagomé system $Nd_3Ga_5SiO_{14}$ has been observed through torque magnetometry and neutron scattering experiments. This is the first example of a "clean" f-electron kagomé lattice with a signature of persistent spin fluctuations down to 46 mK.

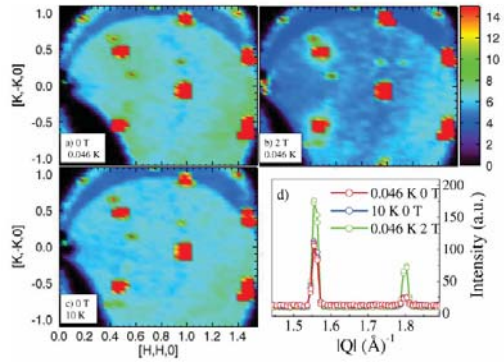

Fig. 2 Diffuse scattering in the [HK0] plane of $Nd_3Ga_5SiO_{14}$. Note the Bragg peaks (red) and rings of diffuse scattering (green). Figures (a) and (b) are at 0.046 mK, but with zero applied field (a) and H = 2 T along the c-axis (b). The collapse of diffuse scattering to magnetic Bragg peaks is clear, as shown in the integrated scans of figure 2(d). Figure 2(c) displays significant diffuse scattering from fluctuating spins even at temperatures as high as 10 K [3].

Acknowledgements

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References

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