Magnetization of Rare Earth Kagome Systems in Pulsed Fields

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Introduction

The rare earth kagome systems $R_3Ga_5SiO_{14}$ (R = Nd or Pr) exhibit cooperative paramagnetism at low temperatures with the possible emergence of a spin liquid phase well below 100 mK. Evidence for correlated spin clusters in these weakly frustrated systems has previously been obtained in neutron scattering experiments carried out at temperatures below 1 K. The present pulsed field (0 – 60 T) low temperature magnetization measurements made on single crystals of $Nd_3Ga_5SiO_{14}$ (NGS) and $Pr_3Ga_5SiO_{14}$ (PGS) have revealed striking differences in the magnetic responses of these two materials.

Experimental

The pulsed field magnetization measurements were made on single crystals of PGS and NGS grown in a floating zone furnace. The applied field, provided by the 60 T long pulse facility at LANL, was directed parallel to the *c*-axes of the crystals. Sample temperatures in the range 1.6 – 50 K were used.

Results and Discussion

Figures 1 and 2 show the magnetization (M) curves for NGS and PGS at 1.6 K. For PGS M does not saturate in fields up to 60 T and shows no plateaus or hysteresis. In contrast, the NGS M does saturate at 1.5 μ_B / Nd, exhibits large hysteresis effects and a plateau region between 0 and 1 T. In measurements made at 4 K it is found that the NGS hysteresis loop has decreased in size and the low field plateau region has becomes less well defined than at 1.6 K.. In PGS M at 4 K tends to higher values than are found at 1.6 K.

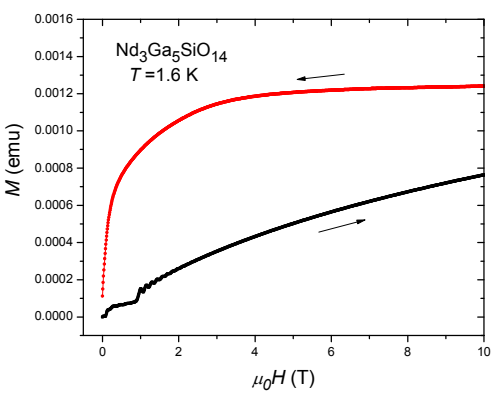

FIG. 1 Magnetization vs. field for NGS at 1.6 K

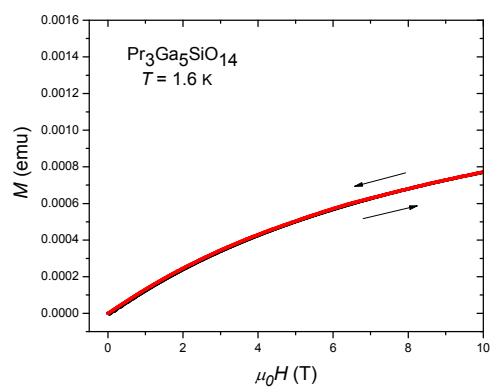

FIG. 2 Magnetization vs. field for PGS at 1.6 K

The marked difference in behavior of the two systems is attributed to the differences in the spin cluster structure and dynamics due to differences in the single ion anisotropy D and in the crystal field splittings of the low-lying states. For NGS $D > 0$ and the gap between the ground state and the first excited state $\Delta \sim 80$ K is larger than in PGS where $\Delta \sim 20$ K and $D < 0$.[1] The exchange couplings J are small with $J \sim 1$ K < $|D|$..

Conclusions

The pulsed field approach offers a new means for determining properties of the spin clusters at low temperatures in these kagome systems. Further experiments at $T < 1$ K are planned.

Acknowledgements

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References

[1] Sanhita Ghosh *et al.* Phys. Rev. B **88**, 094414 (2013).