Investigating the Possibility of a Magnetization Plateau in $Ba_3MnSb_2O_9$

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Introduction

The class of materials $Ba_3MSb_2O_9$ (where M is a 3d electron transition metal), of which the title compound is a member, demonstrates a 2D triangular antiferromagnetic lattice in the a-b plane. Magnetic ordering is constrained in these materials due to the geometrical frustration, however they will generally order antiferromagnetically in a 120 degree spin structure at low temperatures (T_N ~ 3-7 K) due to inter-plane coupling along the c-axis. With the application of high magnetic field along the magnetic easy-axis, a transition to an up-up-down spin configuration is observed via a plateau in the magnetization that is 1/3 the saturation magnetization, which develops from quantum spin effects. This 1/3 plateau has been observed for M = Co (spin ½) and M = Ni (spin 1) by Shirata et al.,[1,2] on polycrystalline samples. These experiments were the motivation for investigating a possible 1/3 magnetization plateau for M = Mn (spin 5/2, T_N ~ 6.5 K) in single crystal samples.

Experimental

Single crystals of $Ba_3MnSb_2O_9$ were measured with B parallel to the a- and c-axis in two ways at the NHMFL Pulsed Field Lab, with fields up to 60 T. An extraction coil technique, which uses the voltage induced in a pair of identical counter wound coils to study the relative magnetization of a magnetically active sample, was used primarily to look for the magnetization plateau. In addition, a TDO[3], which is essentially a self-resonating LC circuit with the sample inside of the inductor, was used to study the relative change of the magnetic susceptibility.

Results and Discussion

From the extraction coil technique we observed a leveling of the relative magnetization around 50 T for the a-axis || B and around 55 T for the c-axis || B. For the TDO measurements we observed, in both orientations, a small slope change around 50 T. Using previous magnetization data (up to 5 T) we were able to estimate that the 1/3 plateau should occur around 16 T and that the 50 T features agreed with the expected field required for full saturation of the magnetization. Since we observe no feature other than at 50 T, we conclude that the 1/3 quantum plateau may not be present in $Ba_3MnSb_2O_9$.

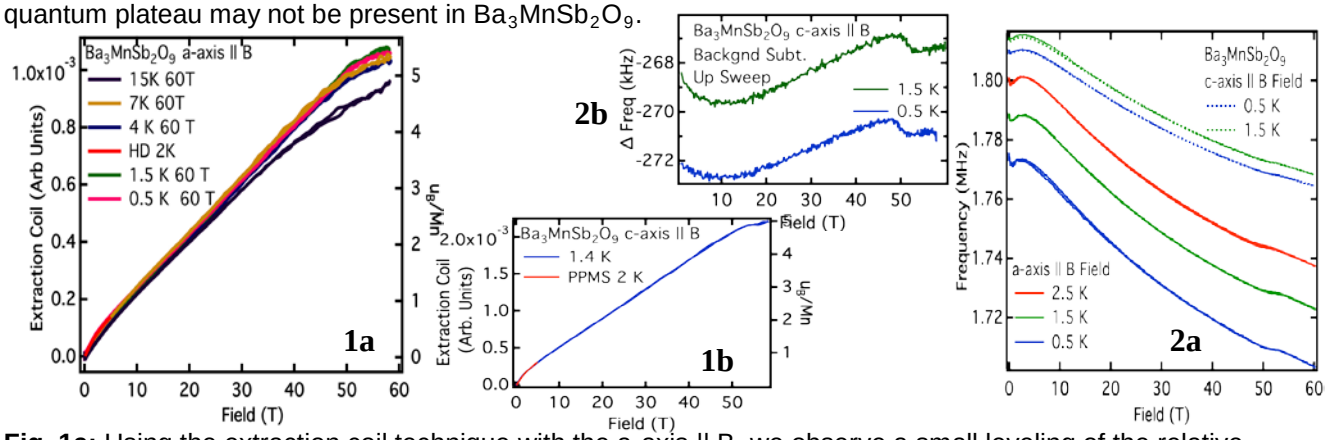

Fig. 1a: Using the extraction coil technique with the a-axis || B, we observe a small leveling of the relative magnetization around 50 T, for a variety of temperatures, which corresponds to the full saturation of the magnetization. **Fig. 1b**: We see the same leveling off with the c-axis || B. **Fig. 2b:** Using a TDO we also see a small slope change for both orientations at ~ 50 T which corresponds to the full saturation of the magnetization. **Fig 2b:** When we subtract the background we can see the slope change more clearly.

Acknowledgements

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References

[1] Shirata, Y., *et al.*, Phys. Rev. Lett., **108**, 057205 (2012).
[2] Shirata, Y., *et al.*, J. Phys. Soc. Jpn., **80**, 093702 (2011).
[3] Ohmichi, E., *et al.*, Rev. Sci. Instrum., **75**, 2094 (2004).