Magnetic Anisotropy in $RuCl_3$ up to 45T From Magnetotropic Coefficient Measurements.

Shekhter, A., Graf, D. (NHMFL); Modic, K. (MPI-Dresden), Ramshaw, B. (Cornell Univ.); Boebinger, G., McDonald, R. (NHMFL)

Introduction

The purpose for this week of hybrid magnet measurements was to explore the angular anisotropy of the Free energy of spin-liquid state in RuCl3 at high magnetic fields. Magentotropic coefficient measurements [1,2] are particularly suited for this purpose as they allow measurements of very small samples (<50ng mass) and they directly inform of the thermodynamic coefficient associated with magnetic anisotropy of the Free energy [1,2]. Figure 1 briefly outline main results of this very successful week of measurements. These measurements — together with measurements of magnetotropic coefficient in pulsed fields up to 64 T — both essential to establish the scale-invariant response of the spin-liquid state in RuCl3 — will be reported in the upcoming publication [2].

Experimental

Figures 1A,B show frequency shift (proportional to magnetotropic coefficient) as we rotate the fields from honeycomb plane to c*-axis (perp. to honeycomb plane) in two different azimuthal planes — sample orientation is shown in inset images. The sketch drawing in B shows the orientation of the in-plane crystal directions with respect to sample shape and orientation of angular scan planes in A and B. Although two azimuthal planes in A,B are only 30 degrees apart, they exhibit a strikingly different magnetic anisotropy, indicating strong singularity of the Free energy near c* direction in the spin-liquid state at 20K (the AFM transition is ~9K at zero field) (see [2] for details) . The inset drawing in A schematically represents the angular dependence of the anisotropic Free energy of RuCl3 in the spin-liquid state, emphasizing the cusp-like singularities converging at c* direction, consistent with the symmetries of the lattice and spin-anisotropy of exchange interactions tied to it (see [2] for details). To test directly the in-plane anisotropy of the free energy we have mounted sample with ab- (honeycomb-) plane perpendicular to the lever. Figure 1C shows the angular dependence of magnetotropic coefficient at 3.5K in the vicinity of the AFM transition. The polar plot clearly indicates non-linear magnetic response at 6 T and 10 T and phase boundary (indicated by red line in Figure 1D) crossing at 8T.

Acknowledgements

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References.

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