Pulsed Field Magnetization of $Co_{10}Ge_3O_{16}$

P.T. Barton (Materials Engineering UC Santa Barbara); V.S. Zapf (NHMFL-PFF, LANL); R.S. Seshadri (Materials Research Laboratory, UCSB, Materials Engineering)

Introduction

Magnetic field-induced phase transitions are often found in antiferromagnetic compounds featuring Co^{2+}, such as the prototypical $CoCl_2$-$2H_2O$.[1] The driving force behind these transitions is the Ising-like single-ion anisotropy of octahedral Co^{2+} that results from the spin-orbit coupling of its d^7 ground state. A recent example is the study of molecular spin-orbit excitations in the spinel $GeCo_2O_4$, using ultrasound spectroscopy and inelastic neutron scattering.[2] Here we investigate a related phase of different stoichiometry $Co_{10}Ge_3O_{16}$, which was discovered by a geologist,[3] but whose physical properties were not thoroughly examined. Our initial experiments on this system revealed a magnetostructural transition and a second transition that is of the first order and is induced by the application of a magnetic field.[4] Here we examine the nature and stability of this phase in high fields.

Results and Discussion

Powder samples of $Co_{10}Ge_3O_{16}$ were prepared by solid-state reaction. Magnetization isotherms, $M(H)$, were measured in short-pulsed fields up to 65 T and down to 2 K. The left figure shows the H-T phase diagram determined by measurements with Quantum Design instruments. The pulsed field experiments are consistent with this phase diagram. Most importantly, the $M(H)$ measurement at low temperature and high field helped investigate the nature of the high-field phase. A magnetization value of ~1.2 μ_B/Co^{2+} is seen at 65 T, which is much less than the expected saturation magnetization value of 3.0. This reduced value suggests that the high-field state is ferrimagnetic.

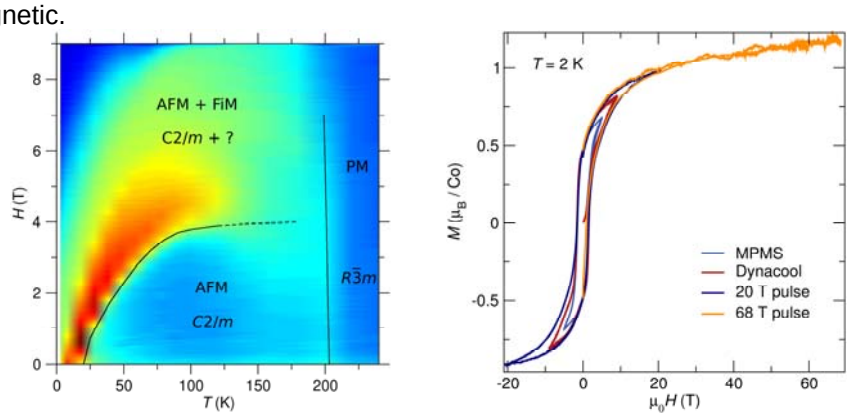

Fig. (left) H-T phase diagram of powder $Co_{10}Ge_3O_{16}$. [4] (right) $M(H)$ of powder $Co_{10}Ge_3O_{16}$ at T = 2 K, as measured by Quantum Design instruments and the pulsed field facility at Los Alamos.

Conclusions

$Co_{10}Ge_3O_{16}$ exhibits an interesting magnetic field induced phase transition to a ferrimagnetic state. The pulsed field experiments show that this state is robust and has a magnetization of ~1.2 μ_B/Co^{2+} at 65 T. This work is being combined with high-field neutron experiments (NIST) and modeling to enhance the understanding of the field-induced state.

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