SUPPRESSION OF ANTIFERROMAGNETISM IN Pr$_3$In

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Introduction

The study of induced moment magnetism in singlet-triplet systems has been an important chapter in the understanding of magnetism in condensed matter physics. Recent neutron diffraction, magnetic susceptibility and specific heat measurements reported by Christianson et al. [1] show that the Pr$_3$In compound exhibits induced moment antiferromagnetic order with $T_N=11.4$K. Our motivation is to explore the evolution of the magnetic order with magnetic field.

Experimental

As a first exploratory study, specific heat was measured at the 15T superconducting magnet at NHMFL-LANL at $H=0$T and $H=15$T (see Fig. 1). The magnetic contribution to the specific heat $C_m$ was obtained after subtracting the lattice contribution using previous[2] measurements of the La$_3$In specific heat following the procedure described by Christianson et al. [1].

Results and Discussion

At low temperatures, $C_m/T$ is a decreasing function of $T$ corresponding to a hyperfine contribution from the Pr nucleus. It is observed that this low-$T$ nuclear feature is shifted towards higher temperatures as the magnetic field is increased. On the other hand, for $T > 4$K, $C_m/T$ is smaller at high magnetic fields. We speculate that the magnetic field overcomes the antiferromagnetic interaction that is responsible for the internal field that induces the moment on the Pr site, reverting the system to a pure crystal field system. To explore this hypothesis, we include in Fig.1 a Schottky specific heat calculated for the following crystal field scheme [3]: $\Gamma_1$ singlet ($E_1=0$ meV), $\Gamma_4$ triplet ($E_4=7$ meV), $\Gamma_1$ doublet ($E_2=12$ meV), and $\Gamma_5$ triplet ($E_5=28$ meV), where the splitting of the levels due to the field $H=15$T has been taken into account.

Conclusions

The behavior in the specific heat as magnetic field is increased from 0 to 15 T shows a very strong effect of the field. The approximate agreement with the Schottky specific heat suggests that the field destroys the condition necessary for inducing the moment at the Pr site, reverting the system to simple crystal field physics. To further understand this fascinating physics, new measurements of specific heat and magnetic susceptibility at different values of magnetic field will be performed.

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References