Calorimetry, Magnetostriction and Thermal Expansion Results in Pr$_3$In

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Introduction

Pr$_3$In is a compound showing induced moment magnetism in a singlet-triplet system. It exhibits induced moment antiferromagnetic (AF) order at $T_N$=11.4 K [1]. Previous specific heat and magneto-caloric effect (MCE) measurements on a single crystal sample of Pr$_3$In performed at NHMFL-LANL showed that a phase transition occurs near 1.9 T below 11 K [2]. Interestingly [3], on polycrystalline Pr$_3$In, the magneto-caloric effect shows two field induced phase boundaries at about 0.6 T and 1.4 T below 11 K (See Fig.1.a). In the present experiment, we aimed at confirming the MCE results on polycrystalline Pr$_3$In by measuring specific heat, magnetostriction and thermal expansion at low temperatures and magnetic fields up to 15 T.

Experimental

Measurements were carried out in a 15T superconducting magnet equipped with a VTI at the NHMFL in Los Alamos, NM. The thermal relaxation time method was used to measure the specific heat. The magnetic contribution to the specific heat $C_{\text{mag}}$ was obtained after subtracting the lattice contribution obtained from measurements on the non magnetic analog La$_3$In. The lattice length changes were measured using a Ti capacitive dilatometry cell [4]. In the present set-up, the cell and sample sit in vacuum in a conical seal in the VTI. The capacitance was set at 11.5 pF at room temperature. Sample was polished down so as to obtain two opposite parallel flat faces and $L$ = 3 mm.

Results and Discussion

Specific heat measurements unveil a very small feature for the AF phase transition, noticeable below 2T only (not shown). A peak in the coefficient of thermal expansion is observed at $T_N$ (not shown) the magnitude of which is considerably reduced above 2.5 T but allows it to follow $T_N$ up to 8 T nevertheless. Thermal expansion measurements manifest a large field-induced volume expansion upon cooling below 50 K as shown on Fig.1.b. Fig.1.c shows kinks at about 0.6, 1.2 and 1.9 T in the coefficient of linear magnetostriction below $T_N$ confirming the MCE findings. Data analysis is still in progress.

Fig.1. (a) ($\mu_0 H$, $T$) phase diagram for polycrystalline Pr$_3$In from specific heat, thermal expansion, MCE and magnetostriction measurements. (b) Relative amount of thermal expansion at several different magnetic fields (cell effect not corrected). Inset: zoom in on the 0, 0.5 and 0.9 T curves. (c) Coefficient of linear magnetostriction at several different temperatures.

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References