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MAGNETIC PHASE DIAGRAM OF Dy_3Co SINGLE CRYSTAL*

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A detailed study of Dy_3Co single crystal in moderate magnetic fields is presented. It forms the orthorhombic structure (Fe_3C-type, space group Pnma) and orders antiferromagnetically (AF) at $T_N = 72$ K. At least three additional AF phases exist below T_N with corresponding transition temperatures $T_1 = 43$ K, $T_2 = 33$ K and $T_3 = 24$ K, respectively. Step-like metamagnetic transitions were observed along all three crystallographic axes. The respective complex magnetic phase diagrams are presented.

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1. Introduction

The intermetallic compound Dy_3Co crystallizes in the orthorhombic structure of the Fe_3C-type [1, 2] where Dy atoms occupy two sites $4c$ and $8d$, respectively, and Co occupies another $4c$ position. As no magnetic moment was found on Co, the magnetic order is a result of an indirect interaction of Dy moments mediated via conduction electrons [3,4]. The antiferromagnetic (AF) ordering was reported at temperatures below 45 K. Observed metamagnetic behavior accompanied by large magnetoresistance effect along all

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three principal crystallographic axes suggests complex AF structure and rich magnetic phase diagram [4].

Here we report on the new bulk and microscopic results of the high-quality single crystal of Dy_3Co. An updated magnetic phase diagram is presented.

2. Experimental results and discussion

The single crystal of Dy_3Co was prepared by remelting the polycrystalline sample in the high-gradient resistance furnace (for details see [4]). A single crystalline grain of about $1\times1\times1$ mm^3 was cut out of the ingot. The high quality of the crystal was confirmed by neutron diffraction.

The temperature dependence of ac-susceptibility was measured on this crystal in several magnetic fields parallel to the crystallographic axes using the $f = 512$ Hz driving field with $H = 2$ Oe amplitude. A pronounced anomaly was found at $T = 72$ K (see Fig. 1) in zero field suggesting that the AF magnetic ordering occurs already at this temperature, higher than reported in [4]. Additional anomalies exist on the ac-susceptibility, the most pronounced ones at $T = 43$ and 28 K.

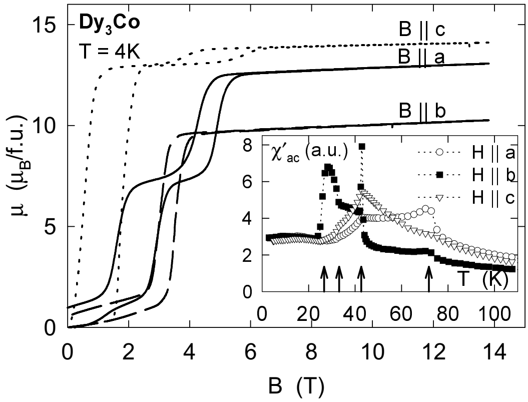

Fig. 1. Magnetization curves along principal crystallographic axes in the ground-state phase. The inset shows the temperature dependencies of ac-susceptibility, the arrows mark the transitions obtained from the neutron diffraction.

Magnetization curves measured both on SQUID and VSM in fields up to 14 T along all three axes exhibit the step-like metamagnetic behavior (with pronounced hysteresis phenomena at temperatures below $\sim$ 20 K). In fields above 6 T the curves saturate, yielding the spontaneous magnetic moment $\mu = 12.23$, 9.40 and 13.64 μ_B/f.u. along a, b and c axis, respectively. With the increasing temperature the sharp transitions become smeared-out, but traces of metamagnetic behavior can be followed up to $T = 72$ K.

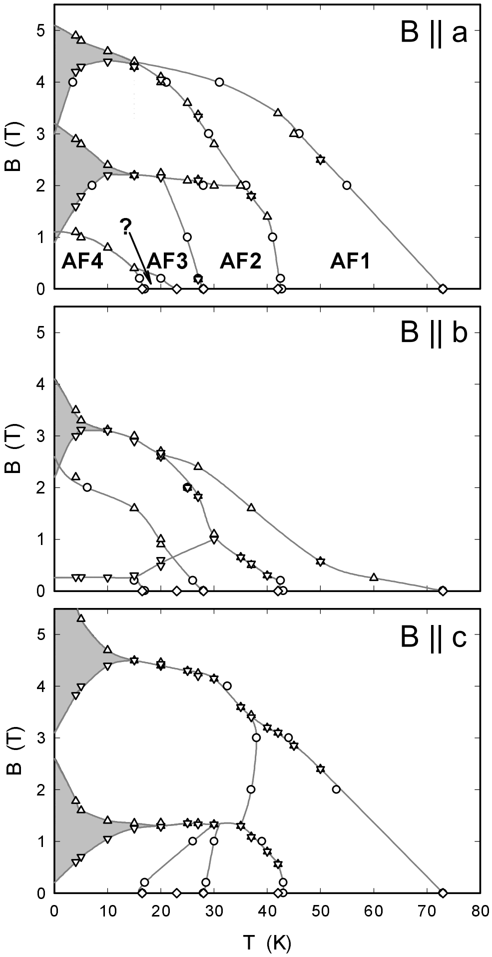

Fig. 2. Magnetic phase diagrams of Dy_3Co in fields parallel to the principal crystallographic directions based on the magnetization ($\triangle$, ∇), ac-susceptibility ($\circ$) and neutron diffraction ($\diamond$) data. The grey areas correspond to the hysteresis phenomena.

This result had motivated the detailed neutron diffraction studies performed in BENSC, HMI, using E4 and E5 diffractometers with incident wavelength $\lambda = 2.4$ Å. The temperature dependence of some magnetic intensities unambiguously proves, that the Néel temperature is indeed $T_{\mathrm{N}} = 72$ K.

The ground-state magnetic structure is characterized by two propagation vectors $\boldsymbol{k}_1 = (0\ 0\ 0)$ and $\boldsymbol{k}_2 = (1/2\ 0\ 1/2)$ [4, 5]. While the $\boldsymbol{k}_2$ propagation disappears at $T = 28$ K, the $\boldsymbol{k}_1$ propagation remains till T_{N}. Contrary to the frequent situation, where an incommensurate magnetic phase appears just below T_{N}, no additional propagation was found in the ordered state.

All these data enabled us to construct the magnetic phase diagram (Fig. 2), but the details of the individual phases has still to be completed. As the saturated magnetization values are far from the maximum theoretical value based on the free Dy^{3+} ion (30 μ_{B}/f.u.), additional metamagnetic transitions can be expected in higher magnetic fields. Moreover, the $\boldsymbol{k}_1$ propagation was observed in the magnetic field $B = 6$ T, indicating that this phase is not yet the field-induced ferromagnetic one.

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