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Thermal, magnetic and electronic properties of non-centrosymmetric $YbPt_2B$

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Abstract

Ternary $YbPt_2B$ crystallizes in the non-centrosymmetric hexagonal $CePt_2B$-type structure (space group $P6_222$). Electrical resistivity, specific heat and magnetic measurements reveal a magnetic instability at 5.6 K. Furthermore, a spin-reorientation of presumably a ferromagnetic type occurs around 1.5 K. The behaviour at low temperature is governed by a rather weak Kondo effect, $T_K \leqslant 1$ K, in the presence of strong crystalline electric field splitting, with a doublet ground state. Besides, the complex magnetic behaviour presumably results from a Dzyaloshinskii–Moriya interaction triggered by the absence of inversion symmetry in the crystal structure. Scaling according to the de Gennes factor traces back magnetic ordering in $YbPt_2B$ to the Rudermann–Kittel–Kasuya–Yoshida (RKKY) interaction and the smooth evolution of the lattice constants and the unit cell volume of $REPt_2B$ (RE = rare earths) refers to the $4f^{13}$ electronic configuration of Yb in $YbPt_2B$.

Keywords: ferromagnetic order, non-centrosymmetric crystal structure, Dzyaloshinskii–Moriya interaction

(Some figures may appear in colour only in the online journal)

1. Introduction

Ternary rare earth (alkaline earth)—noble metal—metalloid (B, Si, Ge) systems have been extensively explored, evidencing a variety of interesting ground states. Among them is heavy fermion superconductivity in absence of inversion symmetry in $CePt_3Si$ [1], BCS superconductivity without inversion symmetry in $BaPtSi_3$ [2] or a diversity of magnetically ordered states in $RE_2Pd_{14+x}B_{5-y}$ [3].

In order to extend the knowledge of such compounds and to continue our systematic investigations of RE-Pt-B systems, the Yb-Pt-B phase diagram has been examined in some detail. These studies revealed a novel ternary compound, $YbPt_2B$, being isostructural to the hexagonal $CePt_2B$ type [4]. In previous studies [5–7] physical properties of $REPt_2B$ have been probed. $CePt_2B$ orders antiferromagnetically at $T_N \approx 2.1$ K [6]. Besides the RKKY interaction, responsible for long range magnetic order, Kondo and crystalline electric field (CEF) effects determine the ground state properties. $PrPt_2B$ was characterised as a metallic antiferromagnet with $T_N = 4.6$ K. $NdPt_2B$, however, was found to exhibit two consecutive phase transitions upon cooling: an antiferromagnetic instability at $T_N = 18$ K followed by ferromagnetism below 10 K [5]. A recent study regarding $TmPt_2B$ evidenced a quite complicated magnetically ordered phase below $T_C = 12.5$ K with predominant ferromagnetic character followed by a spin re-orientation below 6 K [7].

The aim of the present work is to identify physical properties of $YbPt_2B$ by means of x-ray, resistivity, magnetisation and heat capacity measurements. Results obtained should allow to classify the magnetic behaviour of this compound and, moreover, assess the electronic configuration (EC) of Yb, which, in general, can fluctuate between the magnetic $4f^{13}$ and the non-magnetic $4f^{14}$ state. Interesting ground states are expected due to the presence of various mutual interactions (Kondo effect, RKKY interaction, CEF

