Magnetotransport in $(Y_xGd_{1-x})Co_2$ alloys near to magnetic phase boundary

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Abstract

We present experimental results on magnetotransport in $(Y_xGd_{1-x})Co_2$ alloys, where the localized Gd-moments are coupled antiferromagnetically to the itinerant Co 3d electrons. The alloys are paramagnetic for $x > 0.85$. The transport properties of the paramagnetic alloys show Kondo like anomalies. On approaching to the magnetic phase boundary from the paramagnetic region the resistivity reveals non-Fermi liquid (NFL) behaviour, indicating a presence of apparently gap-less magnetic excitations. Large positive magnetoresistivity is observed in in the alloys with magnetic ground state at temperatures $T < T_c$.

Key words: magnetotransport; non-Fermi-liquid;itinerant magnetizm;localized moments.

1. Introduction

Alloys $Y_xGd_{1-x}Co_2$ belong to the family of Laves phase compounds RCo_2 (where R stays for rare earth elements and Y, Sc). In this family, YCo_2 is a strongly enhanced Pauli paramagnet and itinerant electron metamagnet, whereas the ground state of $GdCo_2$ is ferrimagnetic, with the magnetization of the itinerant 3d Co-subsystem directed antiparallel to the localized 4f moments of Gd-sublattice. It has been well established that the 4f-3d exchange interaction is the most important interaction in the RCo_2 compounds as it concerns their magnetic structure.

We have measured electrical resistivity, thermopower and AC susceptibility of polycrystalline samples of $Y_xGd_{1-x}Co_2$ alloys for x in the range of 0 to 1, at temperatures from 0.1 K to 300 K, under magnetic fields up to 15 T.

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2. Results and discussion

The phase diagram of the $Y_xGd_{1-x}Co_2$, as it was inferred from the transport properties and AC susceptibility is presented in Fig. 1. The ordering temperature T_c depends on the content of Y, x, according to the quantum critical scaling relation[1]:

$$T_c = |x - x_c|^{\frac{z}{d+z-2}} \quad (1)$$

with d=3, z=1.2.

There are 3 composition regions of $Y_xGd_{1-x}Co_2$ with distinct behaviors of the transport properties. The system has magnetically ordered ground state at $x < 0.85$. At low Gd content , $0.95 \leq x < 1$, the Gd magnetic moments are independent, and both, ρ and S, show Kondo-type anomalies. Strong enhancement of thermopower minimum at low temperatures (about 20 K) was observed for $x \geq 0.98$, whereas S at high temperatures reveals a monotonic decrease with increasing Gd content[2]. At $0.85 > x > 0.7$ the ground state of the $4f$ localized moment subsystem is ferromagnetic, whereas the itinerant 3d cobalt elec-

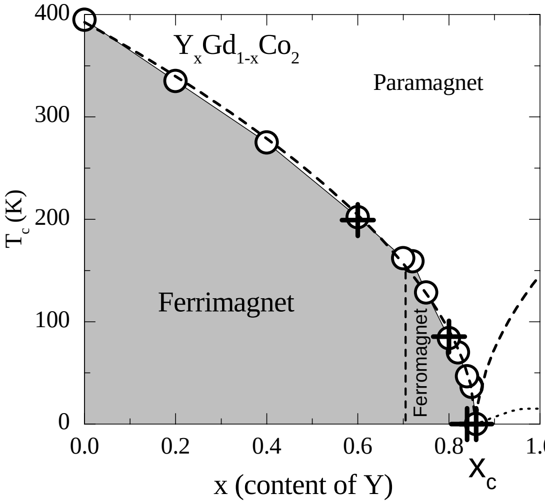

Fig. 1. Phase diagram of the $Y_xGd_{1-x}Co_2$ system. x_c indicates the critical concentration separating the paramagnetic and magnetically ordered regions of the phase diagram. The dashed line represent the quantum critical scaling relation for $T_c(x)$ (Eq. 1). The dotted line in the paramagnetic part marks the region where Kondo-like behavior was observed.

tron system is paramagnetic. At higher Gd content the exchange field of the ordered Gd moments exceeds the critical field for metamagnetic transition and the 3d system undergoes the metamagnetic transition into ordered state, resulting in a ferrimagnitic 3d-4f arrangement.

The magnetoresistivity ($\Delta\rho$) of paramagnetic alloys ($x > 0.85$) is negative. The sign of $\Delta\rho$ is in agreement with the expected suppression of spin fluctuations by external magnetic field. But, $\Delta\rho$ shows strong temperature dependence without any sign of saturation down to 1 K, well below Zeeman splitting energy in field of 15 T, at which $\Delta\rho$ was measured, see Fig. 2.

Close to the onset of the ferromagnetic long range order the resistivity in magnetic field displays a NFL behavior being almost a linear function of temperature down to about 0.1 K, Fig. 3. NFL behaviour is frequently observed in the systems which are close to magnetic instabilities. However, usually external magnetic field restores Fermi-liquid picture, suppressing critical magnetic fluctuations. The field-induced NFL behaviour was observed in antiferromagnetic materials or in metamagnetic systems [3]. In the present compounds, the external magnetic field also induces NFL behaviour, even the system is close to ferromagnetic instability.

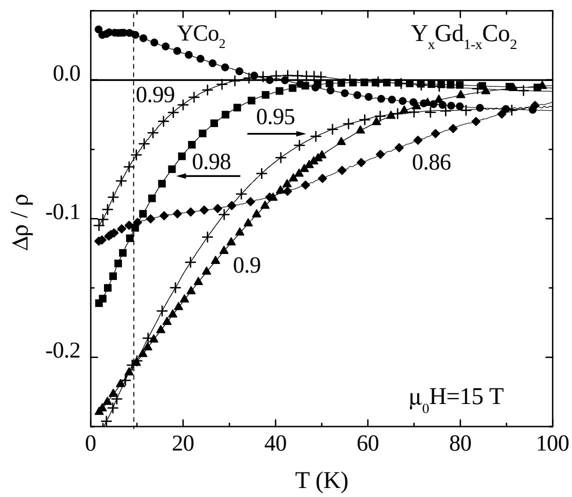

Fig. 2. Magnetoresistivity of paramagnetic samples against temperature. The magnetoresistivity has a strong temperature dependence down to well below Zeeman splitting energy μ_BH, indicated by vertical dashed line.

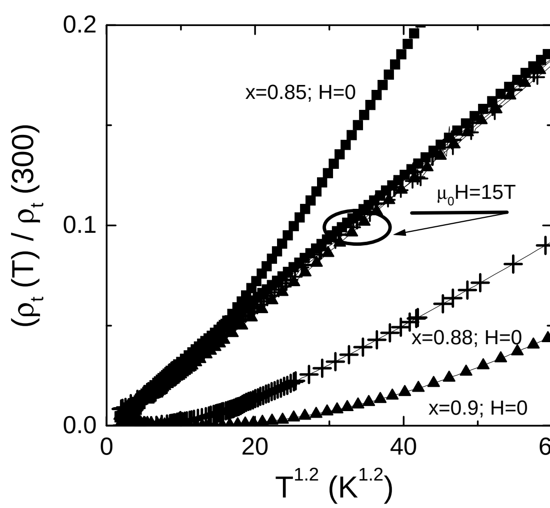

Fig. 3. Normalized temperature dependent part of resistivity $\rho_t = \rho - \rho_0$ vs $T^{1.2}$ for paramagnetic samples. In zero external magnetic field the temperature dependency is close to AT^2, with pre-factor A strongly dependent on x. However in external field the resistivity reveals NFL dependency being proportional to $T^{1.2}$ in a temperature range spanning about two orders of magnitude. Note, all the dependencies in magnetic field map on one common line.

Acknowledgements

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