Resistivity of $CeIn_3$ Single-Crystals Down to 400 mK

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Introduction

$CeIn_3$ is a cubic non Fermi liquid heavy fermion compound ordering in a simple type II antiferromagnetic (AF) structure at T_N = 10.1 K. An applied pressure between 24 and 27.5 kbar induces a transition into a superconductive phase at T_c = 200 mK **[1]** whereas 20 % In / Sn substitution suppresses the magnetic order **[2]**. In magnetic field, 61 (± 2) Tesla are required to suppress the magnetic order where an important increase of the dHvA mass is observed only for certain orientations of **B** as $T_N \rightarrow 0$ **[3]**. In the present series of measurements, we study the electronic properties of $CeIn_3$ at very low temperature.

Experimental

The $CeIn_3$ samples (A, B, C) were cut from single-crystals grown using the self flux method by different groups. For samples B and C, a further annealing at 950°C was carried so as to reduce the residual resistivity. The surface of samples B and C is matt, dark grey *vs*. shiny for A. The samples have an overall plane-parallel shape of 0.2 x 0.2 mm^2 cross section and of ~ 3 (C) and 1.4 (A, B) mm lengths, the longer axis being along the (001) high symmetry axis. Samples B and C were polished prior making contacts. 0.001 platinum wires were used and EPO-TEK H20E-175 silver epoxy baked at 100°C for 90 mns. A LR700 resistance bridge measures the resistance with excitation current 3 mA. At room temperature, R = 8.8 mΩ (A), 2.0 mΩ (B) and 1.3 mΩ (C). Samples were immersed in He^3 where the temperature is decreased by controlling the temperature of the charcoal pump between 4 K and 50 K on the He^3 fridge of the 15TRUS magnet at NHMFL-LANL. The 4 wires resistivity measurements were carried out at fixed field up to 12 T.

Results and Discussion

The resistivity curves are shown between 400 mK and 20 K at 0, 0.5 T and 12 T for sample B in **Fig.1.** At zero field, a transition is observed at 3.1 K that is associated with the superconductivity (SC) of pure Indium (In, T_c = 3.4 K, H_c = 293 Gauss **[4]**). The $CeIn_3$ AF transition is observed at 10 (0.05) K in agreement with **[2]**. At 0.5 T and 400 mK, the residual resistivity is 2 μΩ.cm in $CeIn_3$-A *vs.* 0.6 in C and 0.8 in B. Inside the AF phase, the resistivity data fitted at 0.5 T to a $\rho = \rho_0 + A_n \times T^n$ power law over the entire temperature range 0 to 10 K yield n = 2.40 (0.05) in $CeIn_3$-A and B and n = 2.60 (0.05) in $CeIn_3$–C. The deviation from a pure T^2 behavior holds true at all fields. At 12 T, a field-induced upturn of the resistivity is observed from 3 K in CeIn3-B and CeIn3-C. The field dependence of the resistivity fitted to a linear law over 12 T yields an average $\Delta\rho/\Delta B$ of 0.35 (± 0.05) $\mu\Omega.cm.T^{-1}$ between 4 and 9 K. In all three samples, the field dependence is more steep at 400 mK than at 4 K. Measurement on sample A after annealing is required to conclude whether or not the low temperature upturn is associated with new physics inside $CeIn_3$.

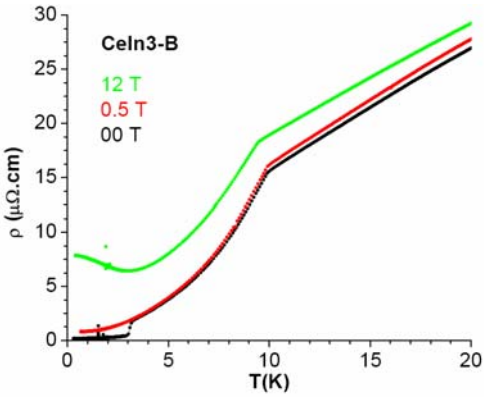

Fig.1. Temperature dependence of the resistivity in CeIn3-B sample at 0, 0.5 and 12 T between 20 and 400 mK

Acknowledgements

This work has been supported by the NSF and the DOE; S. F. acknowledges support from the Seaborg Institute;

References

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