High Field Magnetoresistance of La-doped $PrOs_4Sb_{12}$

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Introduction

$PrOs_4Sb_{12}$ is the first discovered Pr-based heavy fermion superconductor. There is great interest in the origin of the electron mass enhancement in this material, since the usual Kondo-like enhancement is not applicable. We have previously suggested fluctuations of the antiferro-quadrupolar (AFQ) order parameter as a plausible mechanism leading to heavy electrons. Here we report a magnetoresistance study of single-crystalline $Pr_{1-x}La_xOs_4Sb_{12}$ alloys, motivated by the unusual magnetoresistance of the pure compound. The results suggest striking correlations between field-induced AFQ order, m*, and magnetoresistance.

Results and Discussion

The low temperature magnetoresistance of pure $PrOs_4Sb_{12}$ has a characteristic dome structure centered at 9-10 T (Fig. 1a), which has been variously ascribed to either crystalline electric field (CEF) effects or field-induced AFQ order. The height of the dome initially increases with x. Alloys with $x \geq 0.3$ have isotropic f-electron magnetoresistance, characterized by a step-like increase between 8 and 11 T (Fig. 1b). This magnetoresistance is consistent with now-accepted singlet CEF ground state. Exchange and aspherical interactions lead to avoided level crossing in fields of order 10 T.

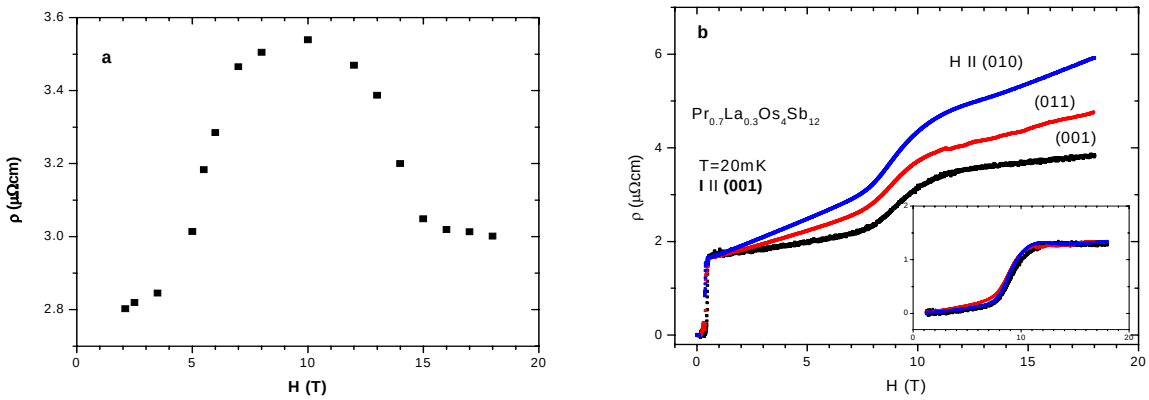

Fig. 1. a) Residual resistivity versus magnetic field for x=0. b) 20 mK resistivity versus magnetic field for x=0.3, for magnetic field along three crystallographic directions. The inset shows the f-electron resistivity for these directions.

Conclusions

The magnetoresistance results imply the existence of a crossover concentration $0.2<x_{cr}<0.3$, previously suggested from heat capacity measurements. This concentration separates alloys with heavy fermion and field-induced AFQ behavior from those that do not exhibit this long-range order and show only modest enhancement of m*. These results imply further that scattering from AFQ fluctuations or AFQ domains is responsible for the dome in the magnetoresistance of pure and weakly La-doped $PrOs_4Sb_{12}$. They are also consistent with our hypothesis of fluctuations of the AFQ order parameter as the primary mechanism of the heavy fermion state.

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References

[1] Rotundu, C.R., *et al.*, Phys. Rev. B **75**, 054416 (2007).