Hc2 Anisotropy of Pu-Superconductors: P01970-E002-PF

E. D. Bauer, O. Ayala-Valenzuela, R. D. McDonald, J. N. Mitchell, P. H. Tobash (LANL, MPA-CMMS)

Introduction

The discovery of superconductivity in $PuCoGa_5$ with a transition temperature of T_c = 18.5 K has generated renewed interest in Pu-based intermetallic compounds [1,2]. $PuCoGa_5$ and $PuRhGa_5$ (T_c=8.7 K) have the same crystal structure as a growing class of tetragonal $Ce_mT_nIn_{2m+3n}$ (T=Co, Rh, Ir) heavy fermion superconductors, suggesting that the structure plays a key role in generating superconductivity in these materials. While a variety of measurements have firmly established that the $CeTIn_5$ compounds are unconventional *d*-wave superconductors, most probably mediated by antiferromagnetic spin fluctuations, it is less clear what drives the high transition temperature in $PuCoGa_5$, which is an order of magnitude larger than all other know Ce- or U-based heavy fermion superconductors. We have recently discovered a new member of this "115" family of superconductors, $PuRhIn_5$, which provides an exciting opportunity to understand the origin of the "high-T_c" in $PuCoGa_5$. The physical properties of $PuRhIn_5$, including powerlaw behavior of the specific heat and a T-linear resistivity indicate that this material is close to an antiferromagnetic quantum critical point, very much like $CeCoIn_5$. We performed measurements of the upper critical field to probe the Pu 5f electron effective mass in $PuRhIn_5$.

Experimental

Electrical resistivity measurements were performed between 0.6 K < T < 300 K and magnetic fields H < 17 T for field applied parallel to the a- and c-axis of single crystals of $PuRhIn_5$ at the LANL pulsed magnetic field facility.

Results and Discussion

Measurements of the upper critical field of $PuRhIn_5$ are shown in **Figure 1**. The initial slope of H_{c2} (H||a) is dH_{c2}/dT = -20 T/K, comparable to that of the heavy fermion superconductor $CeCoIn_5$. Within a spherical Fermi surface approximation, an effective mass of m*=215 m_e is obtained, corresponding to a Sommerfeld coefficient gamma=900 mJ/mol K^2. This is a factor of four times larger than the value estimated from dH_{c2}/dT =-10 T/K of $PuCoGa_5$. These results suggest the possibility that the superconductivity of $PuRhIn_5$ is mediated by antiferromagnetic spin fluctuations, based upon the similarity to $CeCoIn_5$, while superconductivity in $PuCoGa_5$, with its larger characteristic energy scale (smaller gamma), may instead be mediated by valence fluctuations.

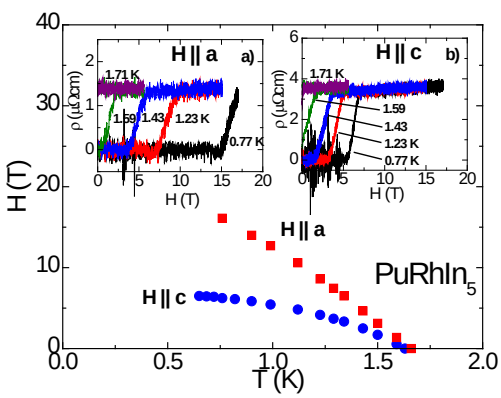

Figure 1: Temperature – magnetic field (T-H) phase diagram of $PuRhIn_5$ for magnetic field applied parallel to the a-axis (red) and c-axis (blue). The insets show the field sweeps from which H_{c2} was determined from the midpoint of the superconducting transition.

Conclusions

Measurements of H_{c2} of $PuRhIn_5$ have been performed at the LANL pulsed magnetic field facility.

Acknowledgements

Work at LANL was performed under the auspices of the U.S. DOE, OBES, Division of Materials Sciences and Engineering, and the LANL LDRD Program.

References

[1] J. L. Sarrao *et al*., Nature **420**, 297 (2002).
[2] F. Wastin *et al*., J. Phys.: Condens. Matter **15** S2279 (2003).