Low Temperature Thermal Expansion of $PuRhIn_5$

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Introduction

Plutonium is arguably the most complex element in the periodic table. It sits near the middle of the actinide series, precisely in between where the 5f electrons are involved in bonding, as in the transition metals, or are localized close to atomic core and do not contribute to bonding, as occurs in the lanthanides. Recently, heavy fermion superconductivity was found in $PuRhIn_5$ at $T_c \approx 1.1K$ [1]. The T-linear behavior of the electrical resistivity from 20K down to T_c, along with a powerlaw behavior in the specific heat and an (extrapolated) Sommerfeld coefficient $te\gamma_0 \approx 350$ mJ/molK^2, suggests proximity to a quantum critical point [1], reminiscent of $CeCoIn_5$ [2]. Analysis of the large initial slope of the upper critical field, which is proportional to the effective mass of the heavy electrons ($dH_{c2}/dT \sim m^{*2}T_c$), yields a value $m^* \approx 230m_e$ for $PuRhIn_5$. Other superconducting properties confirm that $PuRhIn_5$ is a strong type-II superconductor. Because of the recent success in finding SC in $PuRhIn_5$ and its relationship to the isostructural $PuCoIn_5$ and $PuCoGa_5$ we propose to investigate the thermal expansion at low temperatures. Specifically, we are interested in using the Erhenfest relationship to determine a pressure derivative for the T_c of the compound using the thermal expansion coefficient and specific heat data. This could give us an idea for which way the transition should move under pressure and therefore give us an idea for which way it should move on a Doniach-type diagram.

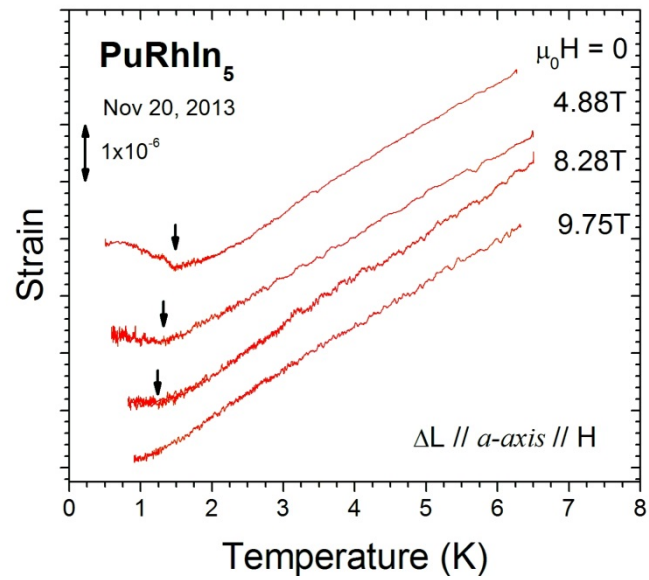

Figure 1 Linear thermal expansion □L/L, also referred as the Strain, plotted vs temperature for PuRhIn5 when the magnetic field and the strain are along the crystallographic *a*-axis.

Experimental

Fig 1 shows the thermal expansion $\Delta L/L$ of a single crystal sample of $PuRhIn_5$ [3] was measured at the NHMFL-LANL in a 15T superconducting magnet furbished with a ^{3}He refrigerator, using a recently developed optical FBG technique. The SC transition at $T_c \approx 1.45K$ is observed clearly in the strain vs temperature at zero applied magnetic field. We observe a shift of the superconducting transition to lower temperatures on application of external magnetic fields μ_0H= 4.88, 8.28 and 9.75T as expected for H//*a*-axis.

Conclusions

Our preliminary proof-of-principle results are very encouraging, since they show that the experimental resolution achieved with our optical FBG technique is sufficient for the proposed determination of the volumetric coefficient of thermal expansion. Future plans include re-measuring the strain vs temperature in fresh samples for ΔL//H//a-axis as well as ΔL//H//c-axis.

Acknowledgements

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References

[1] E. Bauer *et al.*, unpublished.
[2] E. Bauer *et al.*, J. Phys.: Condens. Matt. **24**, 052206 (2012).
[3] E. Bauer *et al.*, Phil. Mag. **92**, 2466-2491 (2012).