Transport Anomaly at a Quantum Critical Point in $CeRhIn_5$

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Introduction

Ce-based compounds exhibit a wide variety of intriguing behavior due to the strongly correlated nature of their f-electrons which are often on the precarious balance of being localized or delocalized. A wonderful example of this is $CeRhIn_5$, which at ambient pressure and zero magnetic field is a local moment antiferromagnet with a Neel temperature of 3.4 K. Upon applying modest amounts of pressure, the antiferromagnetism is suppressed at a nominal quantum critical point, and the f-electrons become delocalized to give way to a 2.3K d-wave superconducting state [1]. The transport behavior under pressure shows many anomalous behaviors including a divergence in the T^2 coefficient of resistivity, leading to a sublinear resistivity precisely at the quantum critical point, which cannot be explained within the currently available theories for quantum criticality. Such behavior must be understood before one can tackle the issue of the mechanism of superconductivity in this and related systems.

An alternative way to tune a system to a quantum critical point is to use magnetic field. In $CeRhIn_5$, magnetization measurements show that a magnetic field of 50 Tesla is required to suppress the antiferromagnetic phase transition [2]. Here we investigate the transport behavior of CeRhIn5 at the field tuned quantum critical point of 50 T and above.

Experimental

Transport measurements on $CeRhIn_5$ were performed in the 92T Multi shot 10mm bore magnet at the pulsed field facility in Los Alamos. The samples for this study were prepared employing a Focused Ion Beam micro-preparation scheme, that has been proven highly reliable and robust in pulsed magnetic fields[3]. The magnetic field was applied along the a-axis of the crystal.

Results and Discussion

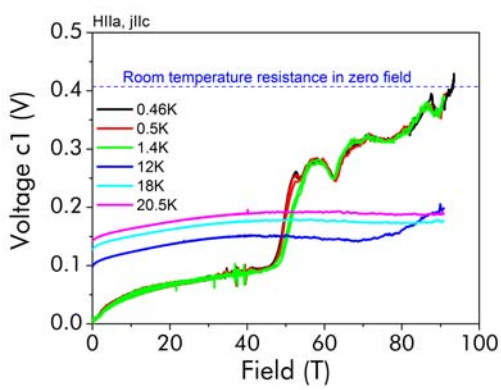

Fig.1 longitudinal voltage of CeRhIn5 with current applied along the c-axis in high magnetic fields.

Our previous experiments in 65T found a pronounced upturn of resistivity is observed upon the field-induced destruction of the Neel order for the configurations (I\\c, H\\a) and (I\\b, H\\c). A broad maximum of resistance at about 35T shrinks and moves to higher fields, well tracing the AFM phase boundary as determined by heat capacity[4]. It is therefore natural to associate the upturn at ~50 T with the destruction of AFM order (see Fig. 1), accompanied by a strong increase in resistance at higher fields, possibly due to the appearance of spin scattering. At the lowest temperatures, in magnetic fields up to 92 T, several field induced anomalies are present, the origin of which are unknown. The field necessary to observe the anomalies increases with increasing temperature. Strikingly, the scattering rate at these high fields is comparable to the scattering rate at room temperature where the f-moments are completely disordered and unscreened.

Conclusions

It appears that the suppression of the AFM order under applied fields in $CeRhIn_5$ is coincident at zero temperature with the onset of a highly resistive state. More work is needed to fully understand this high field state.

Acknowledgements

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References

[1] H. Hegger et al., Phys. Rev. Lett. **84**, 4986 (2000).
[2] H. Shishido et al., J. Phys. Soc. Jpn. 71, 162 (2002), and references therein.
[3] P. J. W. Moll et al., Nature Materials **9**, 628-633 (2010)
[4] L. Jiao, et al. ArXiv:1308:0294 (2013)