MAR13-2012-020050

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Pressure tuning of magnetic fluctuation and superconductivity in $CeCoIn_5$[1]

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One of the greatest challenges to Landau's Fermi liquid theory – the standard theory of metals - is presented by complex materials with strong electronic correlations. The non-Fermi liquid transport and thermodynamic properties of these materials are often explained by the presence of strong quantum critical fluctuations associated with a quantum phase transition that happens at a quantum critical point (QCP). The heavy-fermion material $CeCoIn_5$ is a prototypical system for which its pronounced non-Fermi liquid behavior in the normal state and unconventional superconductivity are thought to arise from the proximity of this system to a QCP [1-5]. Previous experiments address the physics of this QCP by extrapolating results obtained in the normal state, i.e., there were no *direct* probes of antiferromagnetism and quantum criticality in the superconducting state. This motivated us to study the transport in the mixed state, thus revealing the physics of antiferromagnetism and quantum criticality of the underlying normal state [6]. In this talk I will present the results obtained in these studies by measuring the vortex core dissipation under applied hydrostatic pressure (P). The vortex core resistivity increases sharply with decreasing magnetic field (H) and temperature (T) due to quasiparticle scattering on critical antiferromagnetic fluctuations. This behavior is greatly suppressed with increasing P. Using our experimental results, we obtained an explicit equation for the antiferromagnetic boundary inside the superconducting dome and constructed an $H-T-P$ phase diagram. This work provides direct evidence for a quantum critical line inside the superconducting phase and reveals the close relationship between quantum criticality, antiferromagnetism, and superconductivity.

In collaboration with T. Hu, H. Xiao, T. A. Sayles, M. Dzero, and M. B. Maple.

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[1]Research supported by NSF DMR 1006606.