QUANTUM CRITICALITY AND SUPERCONDUCTING PAIRING MECHANISM IN $Ce_{1-X}Yb_XCoIn_5$ ALLOYS

Carmen C. Almasan[1], Yogesh P. Singh[1], Tao Hu[1], Ivy K. Lum[2], Benjamin D. White[2], Maxim Dzero[1], and M. Brian Maple[2]

[1]*Kent State University, Kent, USA*
[2]*University of California, San Diego, USA*

The temperature-pressure (T – P) and temperature-doping (T – x) phase diagrams of most unconventional superconductors reveal an intricate interplay between magnetism and superconductivity: superconductivity emerges from an antiferromagnetic parent state upon doping with an excess of charge carriers, suggesting that the superconducting pairing mechanism could be related to the antiferromagnetic instability of the parent state. Moreover, there is overwhelming evidence for an underlying quantum phase transition (QPT) at a quantum critical point (QCP) separating magnetic and paramagnetic states within the superconducting phase, suggesting that strong magnetic fluctuations play a key role in the emergence of superconductivity, while the non-Fermi liquid (NFL) transport and thermodynamic properties of these materials are often explained by the presence of strong quantum critical fluctuations associated with this QPT. Nevertheless, no signatures of magnetic fluctuations are found in the heavy-fermion superconductors $PuCoGa_5$ and $PuRhGa_5$. The heavy-fermion $CeCoIn_5$ is a prototypical system for which its pronounced NFL behavior in the normal state and unconventional superconductivity are thought to arise from the proximity of this system to a QCP. We present measurements of the vortex core dissipation under applied pressure and magnetic field (*H*) that reveal the antiferromagnetism and quantum criticality of the underlying normal state under the superconducting dome of $CeCoIn_5$ [1]. These measurements also allow the construction of an *H-T-P* phase diagram and of a quantum critical line. Furthermore, we also show that the full suppression of the QCP in $CeCoIn_5$ by doping with Yb has surprisingly little impact on both superconductivity and the NFL behavior [2-4]. All these experimental results strongly suggest that, although $Ce_{1-x}Yb_xCoIn_5$ is close to a magnetic instability that would favor the exchange of spin fluctuations between the conduction electrons as the Cooper pairing mechanism, an alternative mechanism for Cooper pairing is at play: hybridization between conduction and localized Ce *f*-electron states, with Cooper pairing developing primarily on the large Fermi surface. In addition, the robustness of the NFL behavior implies that this behavior could be a new state of matter in its own right rather than a consequence of the underlying quantum phase transition.

This work has been supported by the National Science Foundation (grant NSF DMR-1505826) at KSU and by the U.S. Department of Energy (grant DE-FG02-04ER46105) at UCSD.

[1] T. Hu et al., Phys. Rev. Lett. **108**, 056401 (2012).
[2] T. Hu et al., PNAS **110**, 7160 (2013).
[3] Y. Singh et al., Phys. Rev. B **89**, 115106 (2014).
[4] Y. Singh et al, Phys. Rev. B **91**, 174506 (2015).

Category: QC
Email: calmasan@kent.edu