MAR14-2013-020067

Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Time reversal symmetry breaking in heavy fermion superconductors[1]

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Heavy fermion materials have been of interest for decades because of the numerous ordered phases they exhibit at low temperatures, often resulting in novel bulk properties including various forms of magnetic ordering and unconventional superconductivity. A full understanding of these phases and their associated order parameters requires knowledge of their corresponding symmetries. In this talk we discuss specifically the role of time reversal symmetry (TRS) breaking, as probed by polar Kerr effect (PKE) measurements, in the canonical heavy fermion superconductors UPt_3 and URu_2Si_2. In UPt_3, we observe the onset of PKE below a temperature $T_{\rm Kerr}$ that coincides with the low temperature "B phase" superconducting transition temperature $T_{c-} \sim 480$mK. In contrast, no change in Kerr effect is observed through either the high temperature "A phase" superconducting transition at $T_{c+} \sim 550$mK or the small-moment antiferromagnetic (AF) transition at $T_N \sim 5$K. These results indicate that TRS is broken only in the B phase, independently of the higher temperature AF order, thus placing strong restrictions on the theory of superconductivity in this system. The case of URu_2Si_2 is more complex. At relatively high temperatures, there is a Kerr effect associated with the so-called "hidden order" (HO) transition at $T_{HO} \sim 17.5$K whose magnitude appears to depend on impurity concentration. At lower temperatures, an additional Kerr signal appears below the superconducting transition $T_c \sim 1.5$K, which is independent of impurity concentration and which can be trained independently of the HO signal in an external magnetic field. Finally, we consistently observe an anomaly in the Kerr data at $\sim 0.8 - 1$K whose origins remain a puzzle, suggesting that there is more to be learned about URu_2Si_2 within the superconducting state.

[1]This work was supported by the Department of Energy Office of Science under contract nos. DE-AC02-76SF00515 and DE-FG02-05ER46248.