DOPED MOTT INSULATOR PHYSICS IN THE *f*-ELECTRON SUPERCONDUCTORS $CeIn_3$ – AN INVESTIGATION

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Introduction

The pressure-induced *f*-electron superconductor $CeIn_3$ is an antiferromagnet below 10 K at ambient pressure, exhibiting superconductivity above a critical pressure of 25.5 Kbar, with T_c ~ 0.2 K [ref. 1]. Traditionally, $CeIn_3$ has been considered a prototypical localised *f*-electron antiferromagnet on account of the large sections of free-electron like (i.e. light effective mass) Fermi surface and large moment (~70-90% of the free moment) in the antiferromagnetic phase. Our recent dHvA experiments on $CeIn_3$ aim to ascertain whether there is hidden evidence for SDW-type behaviour by searching for orbits with heavy mass [2], and tracing their evolution with magnetic field. We investigate whether the doped-Mott insulating model can explain the physics of this *f*-electron superconductor.

Results and Discussion

Recent dHvA experiments at low temperatures (down to 30 mK) and high magnetic fields (up to 45 T) in the hybrid magnet at NHMFL, Tallahassee reveal the presence of small, very heavy ellipsoid-shaped pockets (m* as high as $80m_e$) along high symmetry [111] directions (shown in Fig. 1). Novel mechanisms must be considered in order to explain the co-existence of heavy quasiparticle masses indicative of the SDW-type scenario, with large localised moments. An interesting observation is that the pancake-like ellipsoids observed in $CeIn_3$ are the exact 3d analogue of the 2d ellipses expected in the hole-doped Mott insulating descriptions of high temperature superconductors. In this scenario, the experimentally observed ellipsoids in $CeIn_3$ would correspond to itinerant *f*-hole pockets. A 3d-model of a hole-doped Mott insulator is currently being calculated for purposes of comparison. A more detailed understanding of the correspondence between pockets of itinerant holes in a doped Mott insulator, and the heavy ellipsoids in $CeIn_3$ can be obtained by tracing their magnetic field dependence. Rather surprisingly, dHvA measurements performed up to 45 T reveal the steep enhancement of the heavy ellipsoidal masses with magnetic field, shown in Fig. 2. These orbits of mass ~ $25m_e$ at low magnetic fields become as heavy as m* ~ $80m_e$ at magnetic fields of 35 T. We are currently investigating whether this behaviour is consistent with predictions of the doped Mott insulating model, in which the mass enhancement can be explained by a progressive polarisation of the magnetic background from antiferromagnetic to ferromagnetic, thereby affecting the motion of itinerant holes. Experimental evidence may support itinerant *f*-hole pockets in a strongly coupled SDW scenario.

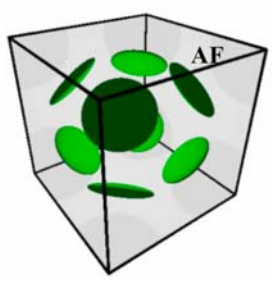

Figure 1: Sketch of the ellipsoidal pockets of *f*-holes within the antiferromagnetic phase of $CeIn_3$.

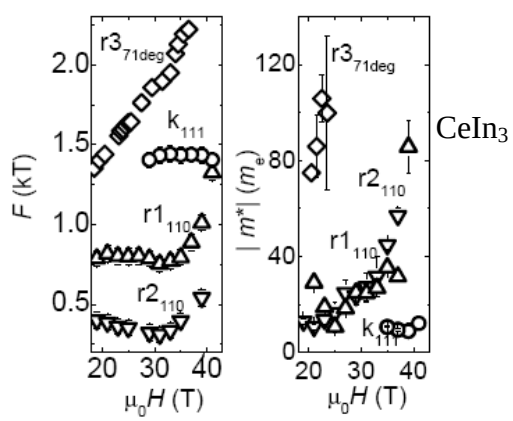

Figure 2: Symbols represent experimentally measured magnetic field-dependence of m* and F for the *f*-hole orbit. The mass increases rapidly at high fields.

References

[1] N. D. Mathur *et al.,* Nature **394**, 39 (1998)
[2] T. Ebihara *et al*., Phys. Rev. Lett. **93**, 246401 (2004)