Fermi Surface Evolution in $CeCoIn_5$ and $LaCoIn_5$ with Cd Substitution

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$CeCoIn_5$ is a heavy fermion superconductor with Tc=2.3K where superconductivity emerges from a metallic state that exhibits strong deviations from the Fermi Liquid theory. Early specific heat and resistivity studies suggested a field-tuned quantum critical point near the upper critical field Hc2 [1], but the absence of long range magnetic order casts doubt on this scenario. However, it was recently shown that Cd substitution induces long range antiferromagnetic order in this system [2]. Since substituting Cd for In acts as an effective negative pressure and also changes the electron count in the conduction band, it is important to understand which of these effects are important in tuning the ground state. One possible way to address this is to determine the Fermi surface (FS) evolution with Cd doping. We have investigated the quantum oscillations of the magnetization (de Haas-van Alphen effect) in single crystals of x=0.025, 0.05, 0.075 and 0.1 Cd replacing In in $CeCoIn_5$ ($LaCoIn_5$) using a torque magnetometer with a Cu-Be cantilever coupled to a capacitive bridge, in the portable dilution refrigerator (He3 refrigerator) using the 35T magnet at NHMFL. dHvA frequencies were previously reported in pure $CeCoIn_5$, in qualitative agreement with band structure calculations assuming itinerant f-electrons [3].

Figures 1a and 1b show the Fast Fourier transform (FFT) spectra of the dHvA oscillations for field oriented close to c-axis in $CeCo(In_{5-x}Cd_x)$ and $LaCo(In_{5-x}Cd_x)$ at 0.1K and 0.4K respectively. The reported branches correspond to the quasi-2D electron (F_3,F_4, F_5) and hole (F_6, F_7) Fermi surfaces, consistent with the previously reported values in the pure compound. Figure 1c shows the doping dependence of the frequencies, with a systematic decrease in the size of the electron sheet in both the Ce- and the La compound. A corresponding increase in the size of the hole sheet (F_6, F_7) is also observed in $LaCo(In_{5-x}Cd_x)$. This is evidence that the Fermi level decreases with Cd doping, as Cd has one less electron than In. The fact that the frequencies decrease at a similar rate for both the Ce and the La compounds, together with a systematically larger FS in $CeCo(In_{5-x}Cd_x)$ compared to the La analog implies that the f-electron remains itinerant in presence of Cd. Further investigations are aimed at the determination of the FS at higher doping levels in the magnetic ground state of $CeCo(In_{5-x}Cd_x)$ and will allow comparison with the antiferromagnetic parent compound $CeRhIn_5$.

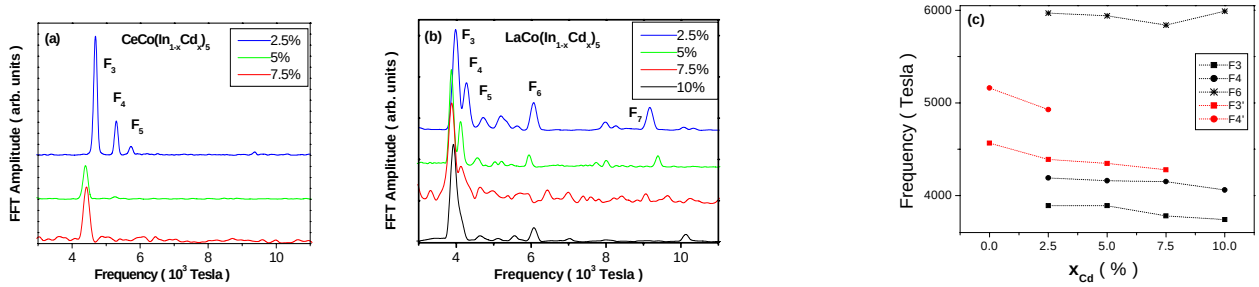

Fig. 1: FFT vs Frequency in (a) $CeCo(In_{5-x}Cd_x)$ and (b) $LaCo(In_{5-x}Cd_x)$. (c) Doping dependence of the dHvA frequencies in $CeCo(In_{5-x}Cd_x)$ (red symbols) and $LaCo(In_{5-x}Cd_x)$ (black symbols).

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References

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