65 T In-plane magnetoresistance anisotropy in CeIrIn5

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Introduction

Recent studies of the heavy fermion antiferromagnet $CeRhIn_5$ indicated a phase transition in fields larger than H*~28T [1, 2, 3]. The transition is accompanied by a large jump in the in-plane resistivity, yet the magnetization remains featureless across the transition. $CeRhIn_5$ is but one of a class of heavy fermion compounds which exhibit a zoo of phase transitions at low temperatures and in the presence of applied field or pressure. Another of these compounds is $CeIrIn_5$. We recently performed magnetoresistance measurements to 65 T in pulsed fields which showed a large increase in the resistivity near 40 T, possibly similar to that in $CeRhIn_5$. Here, we performed additional transport experiments that probe possible in-plane resistivity anisotropy, necessary to discern the behavior of an electronic high field state.

Experimental

Single crystals of $CeIrIn_5$ were microstructured such that simultaneous in-plane – [100] and [010] or [110] and [1-10] – resistivity measurements could be performed at high magnetic fields, as shown in Fig. 1a. The microstructures are particularly suited for transport measurements at high fields, as the aspect ratio of the devices gives enhanced signal to noise in a material whose high conductivity would inhibit measurements on bulk crystals. To investigate the feature at H ~ 40 T, we performed angular-dependent and temperature dependent measurements of the resistivity. This experiment was performed in pulsed fields up to 65 T using a rotator probe in Los Alamos, NM.

Results and Discussion

The magnetoresistance measurements are shown in Fig. 1b. The experiment shows that excellent signal to noise is obtained for measurements on the microstructure. Interestingly, the same resistivity anisotropy present in $CeRhIn_5$ does not appear in $CeIrIn_5$, implying the high field phase is distinct from $CeRhIn_5$. However, large quantum oscillations, up to ~10% of the resistivity appear after the resistivity increase, Fig. 1c., similar to those in CeRhIn5 and CeCoIn5, suggesting a common origin for the high field physics of these compounds. In CeIrIn5 only a few oscillations are visible up to 65 T, and fields of 100 T are necessary to make definitive statements about these features.

Conclusions

The resistivity anisotropy associated with the 40 T feature in $CeIrIn_5$ is distinct from that $CeRhIn_5$. However, both compounds, as well as $CeCoIn_5$ exhibit similar behavior in their quantum oscillations at high fields. Fields of 100 T are necessary to make any quantitative statement about the quantum oscillations in $CeIrIn_5$.

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References

[1] Jiao, L., *et al.*, Proc. Natl. Acad. Sci. U.S.A., **112**, 673–678 (2015).
[2] Moll, P.J.W., *et al.*, Nat. Commun. **6**, 6663 (2015).
[3] Ronning, F. *et al.*, Nature, **548**, 313–317 (2017).

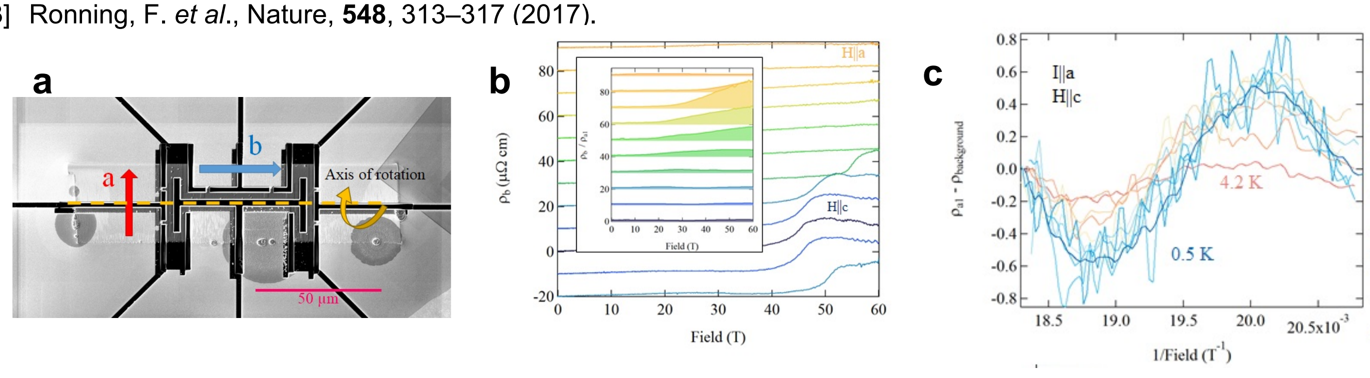

Fig.1 a) Electron beam micrograph of a $CeIrIn_5$ microstructure. Current is injected through the bottom contacts and passes the entire U-shaped structure with all three bars in series. b) Angle dependence of the in-plane resistivity and the resistivity anisotropy (inset). c) Temperature dependence of the quantum oscillations in the in-plane resistivity above 40 T in $CeIrIn_5$.