Quantum Oscillation Measurements in Cerium 235s: P0970-E004-PF and P1970-E008-PF

R. E. Baumbach (LANL, MPA-CMMS); E. D. Bauer (LANL, MPA-CMMS); X. Lu (LANL, MPA-CMMS);
R. D. McDonald (LANL, MPA-CMMS); F. Ronning (LANL, MPA-CMMS); J. D. Thompson (LANL, MPA-CMMS)

Introduction

It is generally accepted that progress in describing quantum criticality depends on determining how the Fermi surface (FS) evolves at the quantum critical point (QCP). To do this, it is necessary to study specimens with exceptionally low crystalline disorder. As a result, the number of heavy fermion (HF) systems where FS reconstruction and QC behavior has been observed is limited (e.g., $CeRhIn_5$). To address this problem, high purity specimens of the HF antiferromagnets $Ce_2Rh_3Ge_5$ and $Ce_2Pt_3Si_5$ were synthesized in the MPA-CMMS group at LANL (T_N = 5.5 K and 6.3 K, respectively). $Ce_2Rh_3Ge_5$ is particularly interesting because the pressure needed to access its QCP is extremely low (P_c ~ 5 kbar) [1]. In contrast, T_N for $Ce_2Pt_3Si_5$ is unchanged up to P < 15 kbar [2]. In our recent measurements using the MagLab facility at LANL, we undertook to measure quantum oscillations in these compounds in order to quantify their FSs and thereby understand their contrasting behavior, as well as to lay the groundwork to study the FS in $Ce_2Rh_3Ge_5$ across the P driven QCP.

Experimental

Tunnel diode oscillator (TDO) and proximity diode oscillator (PDO) measurements were performed for temperatures 0.4 K < T < 30 K and magnetic fields H < 60 T for $Ce_2Rh_3Ge_5$ and $Ce_2Pt_3Si_5$ at the pulsed magnetic field facility at LANL.

Results and Discussion

Unexpectedly, we find that the antiferromagnetic ground state is suppressed to T = 0 at similar magnetic fields (H_c = 23 T and 36 T, respectively) [**Figure 1**] for $Ce_2Rh_3Ge_5$ and $Ce_2Pt_3Si_5$. This result suggests comparable magnetic energy scales in these compounds and is in contrast to what is found in pressure experiments. Therefore, it seems that although these compounds are markedly similar, the mechanism that yields the pressure driven QCP in $Ce_2Rh_3Ge_5$ is not present in $Ce_2Pt_3Si_5$. We are currently investigating differences between these compounds and the mechanisms for their quantum criticality. In particular, our pulsed field measurements allow us to quantify the Fermi surface in each compound, which will be useful to develop a fundamental understanding their physical properties [**Figure 2**].

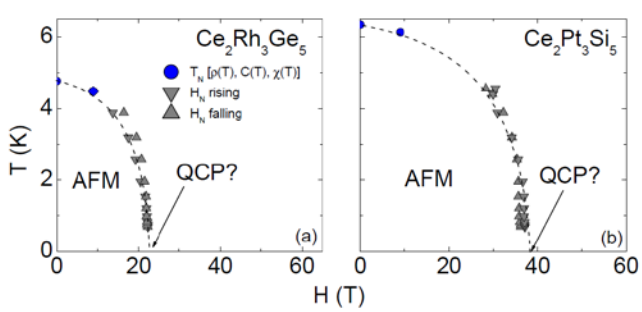

Figure 1: Temperature – magnetic field (T-H) phase diagrams for $Ce_2Rh_3Ge_5$ and $Ce_2Pt_3Si_5$ constructed from TDO/PDO measurements.

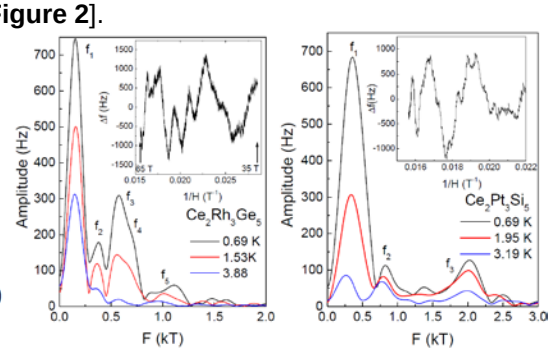

Figure 2: Main panels: Fourier transform of the oscillations in $Ce_2Rh_3Ge_5$ and $Ce_2Pt_3Si_5$. Insets: Raw TDO data at 0.69 K (after background subtraction) showing quantum oscillations.

Conclusions

We have identified previously unknown magnetic field driven quantum phase transitions in $Ce_2Rh_3Ge_5$ and $Ce_2Pt_3Si_5$. We have also measured quantum oscillations at high magnetic fields for both compounds. Together, these results will help to develop an understanding of their quantum critical behavior.

Acknowledgements

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References

[1] Umeo, K., *et al.*, Phys. Rev. B, **64**, 144412 (2001).
[2] Baumbach, R. E., *et al.*, manuscript in preparation.