Title: Unusual Phase Diagram of CeOs4Sb12

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# Unusual Phase Diagram of $CeOs_4Sb_{12}$

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## Introduction

Filled skutterudite compounds, with the formula $MT_4X_{12}$, where M is an alkali metal, alkaline-earth, lanthanide, or actinide, T is Fe, Ru, or Os, and X is P, As, or Sb, display a wide variety of interesting phenomena caused by strong electron correlations [1]. Among these, the three compounds $CeOs_4Sb_{12}$, PrOs4$Sb_{12}$, and NdOs4$Sb_{12}$, formed by employing Periodic Table neighbors for M, span the range from an antiferromagnetic (AFM) semimetal (M = Ce) via a 1.85 K unconventional (quadrupolar-fluctuation mediated) superconductor (M = Pr) to a 1 K ferromagnet (FM; M = Nd) [1]. In the course of an extended study of these compounds, we uncovered an unusual phase diagram for $CeOs_4Sb_{12}$ [1].

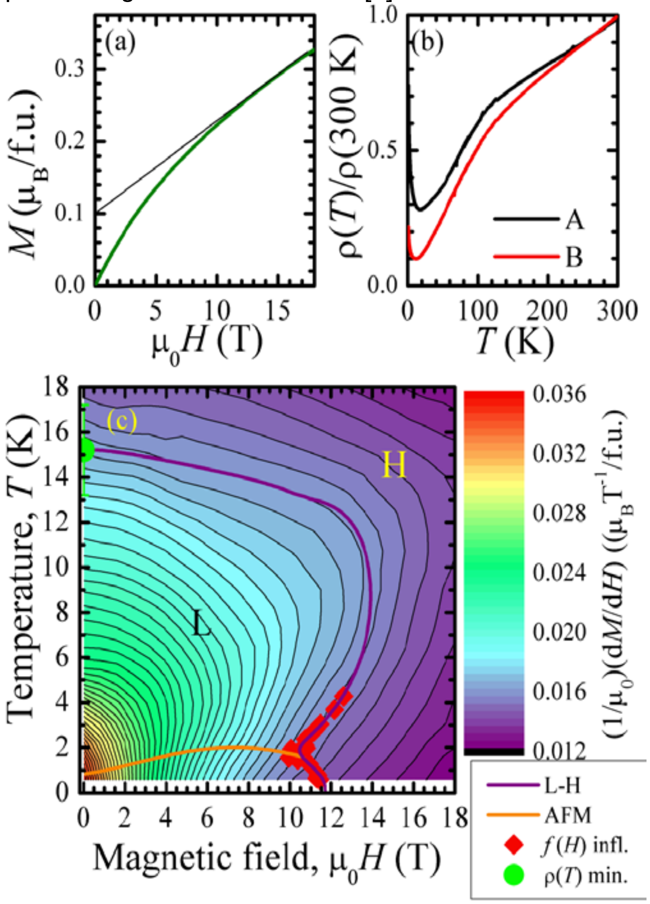


Figure 1. Data and phase diagram for $CeOs_4Sb_{12}$.

## Results and Discussion

To delineate the various low-temperature phases, data from a pulsed-field extraction magnetometer at NHMFL Los Alamos [Fig 1(a)] and a SQUID magnetometer at Warwick University were used to map out the differential susceptibility as a function of field and temperature [Fig.1(c)]. These data were compared with resistivity measured at Fresno State [Fig. 1(b)] and Proximity-Detector-Oscillator MHz conductivity in pulsed fields at Los Alamos [1].

The resulting phase diagram of $CeOs_4Sb_{12}$ is determined by competing energy scales. The purple L-H boundary denotes a valence transition; in the L phase, the 4*f* electrons act as very heavy band quasiparticles. However, as field and/or temperature rises, it becomes more energetically favorable for the 4*f* electrons to become localized on their parent Ce ions. Unusually, a backwards curvature of the L-H boundary occurs in the vicinity of the low-temperature AFM state [orange phase boundary in Fig. 1(c)]. This is possibly due to antiferromagnetic fluctuations, that act to destabilize the L phase, pulling the L to H boundary to lower fields as temperature is reduced toward the AFM transition. Once antiferromagnetic order is established, the free-energy landscape changes and it appears that the L phase becomes more stable as the temperature is lowered further, such that the L to H and antiferromagnetic phase boundaries coincide and move to higher fields. This interplay between the Fermi-surface reconstruction (the L to H transition) and the antiferromagnetism can arise because these phases are inextricably linked.

Not only are the energy scales of the two transitions similar in this part of the phase diagram, but also the AFM is expected to arise from the formation of a spin-density wave, a process that depends crucially on the Fermi surface and its fluctuations [1].

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## References

[1] P.-C. Ho, et al., *Phys. Rev. B*. **94**, 205140 (2016).