# Pressure Evolution of the Néel Critical Field and a Field Induced Lifshitz Transition in $CeIn_3$

K.M. Purcell, D. Graf, M. Kano, J. Bourg, E.C. Palm, T. Murphy, S. Tozer (NHMFL-FSU); C. Mielke, R. McDonald (NHMFL-LANL); J. Cooley (LANL); Rongwei Hu (Brown U, Physics); C. Petrovic (Brookhaven Nat. Lab); P. Schlottmann (FSU, Physics); T. Ebihara (Shizuoka U, Physics)

## Introduction

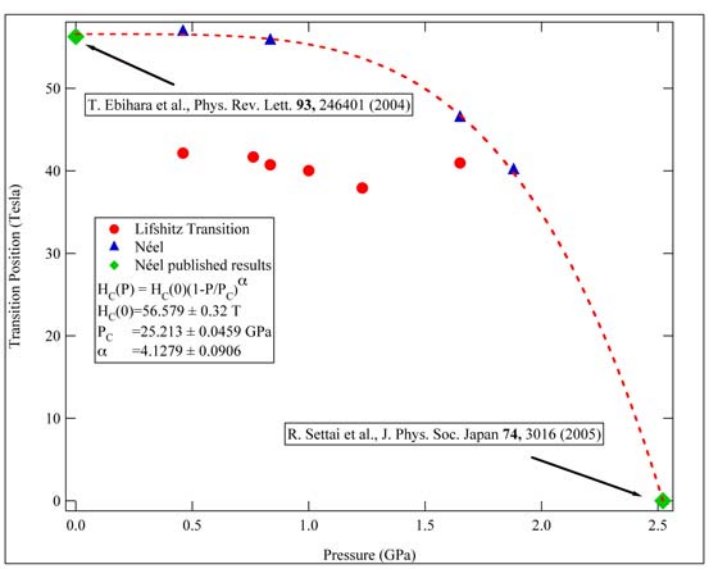
$CeIn_3$ belongs to a family of Ce-based antiferromagnets that exhibit pressure-induced superconductivity in the vicinity of the critical pressure where the Néel temperature is suppressed to zero.[1] In this work, we studied the pressure dependence of an observed anomaly in the skin depth of single crystal $CeIn_3$ well within the Néel ordered phase that takes place near a reported Lifshitz transition [2] utilizing the change in the resonant frequency of a tunnel diode oscillator (TDO). This anomaly shares the same characteristic shape as seen in the reported pressure induced Lifshitz transition in elemental zinc.[3] We also report the previously unobserved high field antiferromagnetic H-P phase boundary, seen as a change in the slope of the normalized frequency. This is the same change in slope that one observes when measuring the skin depth of $CeIn_3$ as it is cooled through the Néel temperature and antiferromagnetically orders.

## Experimental

A single crystal $CeIn_3$ sample 50 microns thick and 300 micron in diameter was placed in resonant coil in a plastic diamond anvil cell in order to measure the pressure dependence of an observed anomaly in the skin depth and the high field Néel phase boundary. Experiments were performed in three magnet systems, the 60 T Long Pulse, 50 T low power and the 65 T short pulse magnet located at NHMFL's LANL pulsed field facility in a Helium-3 refrigerator with. Additional measurements were carried out in the 35 T resistive magnet at the DC Field facility.

## Results and Discussion

The position of the observed anomaly and the antiferromagnetic transition were determined by evaluating the field derivatives of the normalized frequency and plotted as a function of pressure at 400 mK and 1.5 K. Only the reconstructed phase diagram at 1.5 K is shown in accompanying figure. A power law scaling of the critical field yielded a 4$^{th}$ order fit that is in agreement with the values expected from published high field ambient pressure and high pressure zero field measurements. The anomaly believed to be a result of the collapse of f-hole pockets of the Fermi surface is driven to lower fields with pressure until ~1.5 GPa. It is then seen to increase with pressure and disappear at the antiferromagnetic phase boundary. The kink in the trend of the anomaly was seen at both temperatures, and may be attributed to the reported change in the nature of the f-electons within the Néel ordered phase from localized to itinerant at 1.5 GPa as seen in NQR measurements.[4] Further measurements are underway to observe quantum oscillatory behavior to confirm and further explore the topological change at point of the anomaly and the nature of the f-electrons in the vicinity of the critical Néel field.




## Acknowledgements

We would like to thank N. Harrison for helpful discussions. This work was supported by NNSA through DOE DE-FG52-06NA26193, NSF Cooperative Agreement No. DMR-0084173, and the State of Florida.

## References

[1] Mathur, N.D., et al. Nature **394**, 39-43 (1998)
[2] Sebastian, S.E., et al., unpublished
[3] Zarg, A.B., J. Phys.: Condens. Matter **14**, 8795 (2002).
[4] Thessieu, C., Physica B **281&282**, 9 (2000).