Light Mass in Chromium from 0.3 - 0.8 GPa

W.A. Coniglio, R. L. Stillwell, S.W. Tozer (National High Magnetic Field Laboratory)

Pure chromium is a room temperature antiferromagnet with a Neél temperature of 311 K. Coupled charge and spin density waves persist up to this temperature at zero magnetic field. The Fermiology is quite complex, and quantum oscillations are dominated by many interfering orbits that produce a complicated spectrum. The interference is due to nesting of pockets on the Fermi surface.[1]

In the 60 T long pulse magnet using a tunnel diode oscillator with a sample inside a diamond anvil cell, we obtained data between 0.365 K and 130 K at hydrostatic pressures from 0.3–0.8 GPa on two samples. Example data is shown in Fig. 1. As in DC field, we observe a quantum oscillation orbit that persists to a remarkable 95 K. We also observe a previously unreported set of orbits between 3–4 kT.

A portion of this experiment was dedicated to understanding how to best collect data in the entirely unique 60 T long pulse magnet at Los Alamos National Laboratory. We learned how the power supply ripple affects a TDO when the diode and associated circuitry experiences the maximum field of the magnet. We also developed a breakthrough technique for ensuring reliable operation of the oscillator without wasting valuable pulses on diagnostics. We have developed custom electronics to bias the oscillator from a digital-analog converter with high precision and stability. The digital controller allows update rates as high as 500 kHz, and the analog filtering is set accordingly. By programming the controller to sweep the bias up and down in a predetermined fashion, we may explore the entire bias range of the oscillator repeatedly in as little as 1.5 ms during the magnet pulse, giving us unprecedented information about the behavior of the oscillator at high field from only a single magnet pulse.

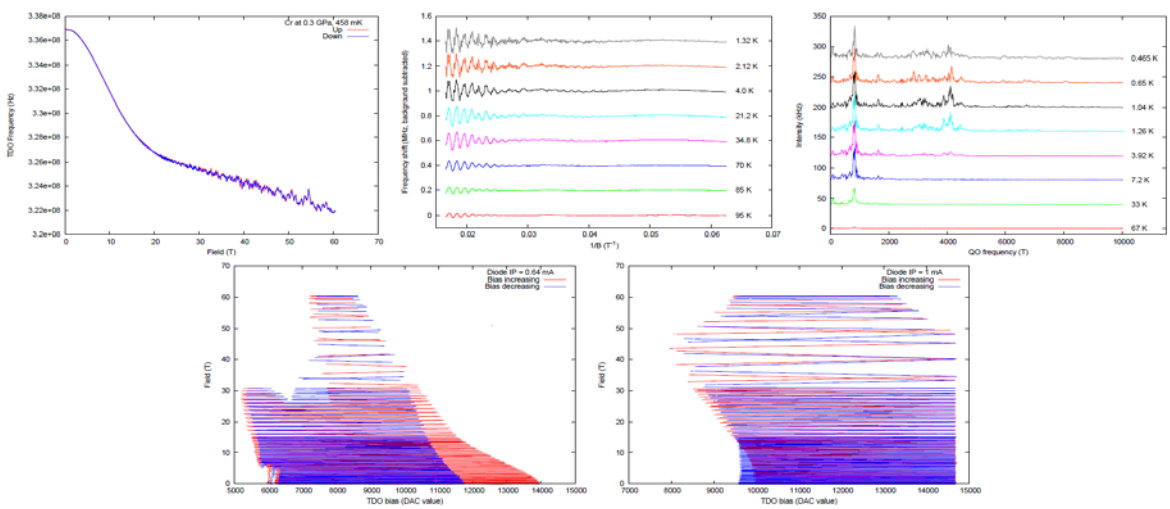

FIG. 1: Left: Example TDO frequency vs. field at low temperature. Middle: Quantum oscillations persist to at least 95 K with the sample under 0.3 GPa of pressure. Right: The quantum oscillation spectrum as a function of temperature at 0.8 GPa in a different sample. Bottom left and right: TDO bias range as a function of field. Red indicates the range available when the bias is increasing;blue indicates the accessible range when bias is decreasing. Up and down magnet sweeps are included.

Acknowledgement

This work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. Department of Energy.

References

[1] Stillwell, R.L.; Graf, D.E.; Coniglio, W.A.; Murphy, T.P.; Palm, E.C.; Park, J.H.; VanGennep, D.; Schlottmann, P. and Tozer, S.W., Pressure-driven Fermi surface reconstruction of chromium. Phys. Rev. B, 88, 125119 (2013)