Quantum Oscillations in $\alpha$-Uranium at Ambient Pressure


Introduction
Uranium goes through a series of lattice changes while cooling ($T \sim 43, 37$ and $23$K), resulting in a charge density wave (CDW) state at low temperatures. It had been previously assumed that to observe quantum oscillations the CDW state must be suppressed by applied pressure. Here, we report the observation of de Haas van Alphen (dHvA) oscillations in $\alpha$-uranium at ambient pressure.

Experimental Results and Discussion
Annealed single crystals of $\alpha$-uranium were mounted to the long, thin lever arm of a cantilever with a matching reference arm (see photo inset to Fig 1a). The cantilever arm resistances were integrated into a Wheatstone bridge circuit, which was monitored during sweeps of the magnetic field. Changes in magnetization of the sample (i.e. dHvA oscillations) create torque on the sample arm of the cantilever which changes the value of the piezoresistive element of the cantilever. A representative field sweep and fast Fourier transform of the data are shown in figure 1. A systematic study of the angular dependence of these sweeps is shown in Fig 1b and 1c, where strong oscillations were observed at $F \sim 600$ and $1400$ T [1] along with a complex set of weaker orbits.

Conclusions
We have compared our results with the measurements of Schirber and Arko [2], where the authors first suppressed the CDW state with high pressure. Though most findings were different, one orbit was found in both experiments. In the $B//a$-axis orientation, the so-called $\beta$ orbit ($F \sim 1400$T) is observed with and without applied pressure which is due to an anisotropic linear compressibility which is weakest along the $a$-axis. This may lead to more pronounced differences between measured orbits for ambient and applied pressure when the magnetic field is orthogonal to the $a$-axis. Measurements at intermediate pressures (i.e. ambient – 8 kbar) are necessary to better understand the evolution of the Fermi surface with pressure.

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References