GHz-FREQUENCY MEASUREMENTS OF α–URANIUM

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Introduction

Upon cooling at ambient pressure α–Uranium exhibits three Charge DensityWave (CDW) transitions. The highest temperature transition, at 42 K is the onset of three CDWs, all incommensurate. Subsequent transitions at temperatures of 38 K and 23 K correspond to the nesting vector in the k_x direction locking into $0.5a^*$ and the nesting vectors in the k_y and k_z directions locking into $^1/_6b^*$ and $^2/_{11}c^*$ respectively. Previous dilatometery measurements [1] reveal the effect of cooling rate on the CDW formation: the equilibrium curve, obtained for cooling rates slower than -5 $Kmin^{-1}$, exhibit a gradual length increase along the a and b direction between 40 K and 20 K, by contrast quench cooling, ~ -5 Ks^{-1}, suppress the length change associated with the CDW formation. Subsequent warming of the quench cooled sample causes the sample length to ratchet towards the equilibrium value between 10 K and 20 K, with the dilatometry remaining hysteretic to temperatures around 90 K. This behavior is attributed to twining and subsequent grain boundary motion.

Experimental

A cavity perturbation technique was employed to measure the microwave response of α–Uranium in the frequency range between 7 GHz and 40 GHz at temperatures between 1.5 K and 300 K and in magnetic fields up to 15 T. A single crystal of α–Uranium was located on the base plate of a cylindrical cavity. In such a configuration the losses due to the microwave currents within the skindepth of the sample decrease the Q-factor of the system and the reduction of the cavity volume increases its frequency. The sample volume was approximately $^1/_{500}{}^{th}$ that of the cavity.

Results and Discussion

The following are the preliminary results of an ongoing investigation. Upon cooling at rates between -2 $Kmin^{-1}$ and -8 $Kmin^{-1}$ a discontinuity in the rate of change of frequency with temperature occurs at around 42 K corresponding to the onset of the negative thermal expansion throughout the temperature range of the CDW transitions. No discontinuities in the Q-factor were observed in this temperature range. Thus far this investigation has focused upon the effect of magnetic field at temperatures below the three CDW transitions. At these low temperatures the Q-factor has a smooth dependence upon field consistent with positive sample magnetoresistance. Figure 1a plots the resonant frequency of the TM_{010} mode as a function of magnetic field for the first and subsequent sweeps after thermally cycling the sample to above 200 K with a cooling rate between -5$Kmin^{-1}$ and -8$Kmin^{-1}$ below 50 K. The first sweep post cooling reveals discontinuous steps in frequency, remarkably similar to the dilatometery jumps upon warming previously reported [1]. Subsequent field sweeps rarely exhibit steps with field dependence of frequency revealing negligible magnetostriction. The dependence of this behavior upon temperature, cooling rate and field orientation is yet to be established. Thermally cycling the sample reestablishes the stepping behavior albeit at different magnetic field intensities. Although the onset and size of the steps varies from one thermal cycle to another, the magnetic field at which the steps occur appears to consistently follow a B^2 behavior (see Figure 1b).

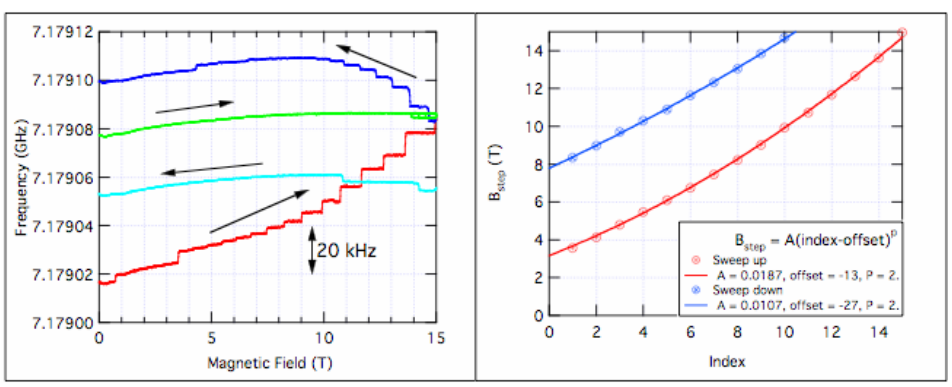

Figure 1a) the magnetic field dependence of the resonant frequency at a temperature of 6 K. **b)** the field intensity of the steps in frequency exhibiting a B^2 dependence.

Conclusions

Ongoing GHz-frequency measurements of α–Uranium in magnetic fields up to 15 T reveal interesting anomalies, at this time thought to be due to the magnetic field coupling to twinned grains of the CDW.

Acknowledgements

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References

[1] Hough *et al.* Phys. Lett. A, **27**, 222 (1968)