Contactless Conductivity of α-U to 143 Tesla

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Introduction

The actinide elements continue to be a source of interest due to their many unconventional physical behaviors. In the case of α-Uranium a series of three cascading charge density wave instabilities are known to exist between 43 and 26 K. It is thought that suppression of those instabilities with applied magnetic field will give rise to a change in conductivity as the carriers repopulate the conduction band. Resistivity measurements as a function of temperature clearly show a change in slope of conductivity, however the effect is rather subtle. With sufficiently high magnetic fields suppression of the charge density waves should give rise to conventional metallic behavior.

Experimental

The single turn magnet system at the NHMFL-Pulsed Field Facility was used to generate magnetic fields in excess of 140 tesla. A contactless radio frequency (rf) transmission probe was developed in the transformer configuration in which a primary transmission coil was placed at one side of a slab like sample and the opposite side of the sample has a secondary receiver coil placed in close proximity. The three elements, transmission coil, sample, and secondary coil are completely analogous to a conventional transformer: primary, core, and secondary.

Results and Discussion

Measurements of the rf contactless conductivityin a millisecond duration pulsed magnet to 60 tesla were first performed on single crystal samples of α-U. Subsequent to those measurements a similar rf contactless experiment was performed on the same sample in the single turn magnet to 143 tesla. Although the data are somewhat noisy, this marks a big success in contactless conductivity measurements at fields beyond 100 tesla. This is the first time that this was accomplished at the NHMFL. A similar trend in the raw data is observed, although the response has a different scaling factor which is simply related to the geometric coupling factor. The data indicate that α-U remains metallic at this extreme of high magnetic field. Subtle changes in the conductivity associated with suppression of the CDW gaps are unfortunately beyond the present resolution. Further efforts are underway to improve the sensitivity of this measurement technique.

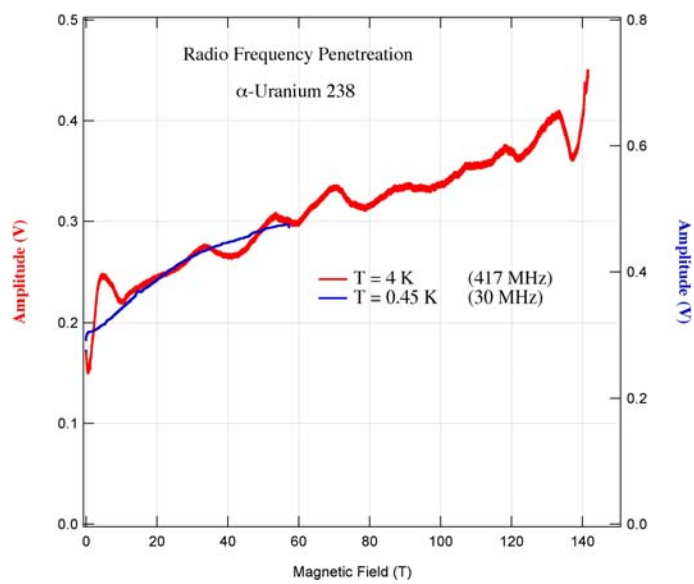

Figure 1. The rf amplitude transmission of α-U measured to 143 T (left) and the rf conductivity measured with a TDO probe with a 60 tesla millisecond pulsed magnet (right).

Conclusions

This experiment marks a new diagnostic capability of the NHMFL and a technique that is of great usefulness to the condensed matter physics community. This work was supported by LANL through the LDRD program, grant number LDRD-DR20070013.

References

[1] Schmiedeshoff, G.M.; Dulguerova, D.; Quan, J.; Touton, S.; Mielke, C.H.; Christianson, A.; Lacerda, A.H.; Palm, E.; Hannahs, S.T.; Murphy, T.; Gay, E.C.; McPheeters, C.C.; Hults, W.L. and Cooley, J.C. *Magnetotransport and superconductivity of alpha-uranium*, Philos. Mag. B, **84** (19), 2001 (2004)