HIGH-FIELD MAGNETIZATION, LONGITUDINAL AND TRANSVERSE MAGNETORESISTANCE OF UlrGe

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UlrfGe crystallizes in the orthorhombic TiNiSi structure and undergoes an antiferromagnetic transition around 14.1 K. The low-temperature longitudinal magnetoresistance (I // B) exhibits a pronounced field-induced step at about 13 T (14 T) and a much weaker step at about 17 T (out of field range) for B // b axis (c axis). No transition was seen for B // a. Here, we report on the magnetization results in fields up to 38 T applied along the principle directions. In addition, we present new magnetoresistance results taken in the transverse (I ⊥ B) configuration in fields up to 18 T applied along the c axis. The data show intriguing differences in comparison to those taken in the longitudinal configuration. The results are discussed in terms of field-induced magnetic transitions and/or Fermi-surface changes.

Isostructural UTX (T = transition metal, X= p-electron element) compounds that crystalize in the orthorhombic TiNiSi structure display a rich variety of moment configurations, unlike those with the hexagonal ZrNiAl structure, which exhibit strong uniaxial c-axis magnetism. Despite intensive studies of both of these isostructural groups, the detailed mechanisms that determine the moment configuration and magnetic anisotropy in UTX compounds remain unclear. Of the UTX compounds with the TiNiSi structure, UlrfGe is one of the most puzzling examples. Bulk studies on polycrystalline UlrfGe showed metallic transport behavior

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but is inconsistent with single-crystal studies in which the resistivity increased sharply below 14 K, indicating the formation of an antiferromagnetic gap in the Fermi surface. Recent pressure experiments suggest internal pressure as an explanation of the apparent contradictions between the behavior of poly- and single-crystalline UIrGe but the idea remains speculative. Further, bulk single-crystal studies that indicated an antiferromagnetic ground state were supported by muon spin resonance experiments, while all neutron diffraction experiments, to date, have failed to verify long-range magnetic order.

Here, we present magnetization measurements in magnetic fields applied along the principal axes. Further, we compare new magnetoresistance results for B // c axis, taken in the transverse (I ⊥ B) configuration, with previous data that were measured in the longitudinal (I // B) configuration. It is worth noting that the measurements were performed on the same set of single crystals used for our previous magnetoresistance studies.

We measured the high-field magnetization of UIrGe in fields up to 38 T applied along the principle axes at the High Field Facility, Van der Waals-Zeeman Institute, University of Amsterdam. The magnetic response of an 11 mg sample of UIrGe was measured using an experimental set-up with a sensitivity of about 3 × 10⁻⁶ A m⁻². Figure 1(a) shows the high-field magnetization with fields applied along the principle axes at 4.2 K. For B // a axis, we observed a linear magnetization with a value of about 0.2 Bohr-magneton at 38 T, which is about 5 and 3 times smaller than the b- or c-axis response, respectively. For B // b axis, a single sharp metamagnetic transition with a step size of approximately 0.2 µB appears at about 12.3 T. No additional step-like transition is seen but there is some indication of a change in the slope of the magnetization curve at about 18 T. In the case of B // c axis, the slope of the magnetization curve clearly increases around 13 T and the step-like transition, again with a step size of about 0.2 µB follows at about 20 T. The transition fields are consistent with phase boundaries derived from magnetoresistance and specific heat measurements.

The magnetoresistance of UIrGe was measured in fields up to 18 T applied along the c axis, using the 20 T superconducting magnet at the Pulsed Field Facility, National High Magnetic Field Laboratory, Los Alamos National Laboratory. A standard four-point technique was employed in the transverse configuration. We measured the temperature dependence of the resistivity at various fixed fields and the field dependence at various fixed temperatures. The overall results were similar to previous data taken in the longitudinal configuration but with some striking differences. At 2.1 K, a field induced transition around 14 T results in a drop in the magnetoresistance to about 85% of the zero field value. The transition field corresponds well with the longitudinal data, but the magnitude of the drop is only a third of what was seen in the longitudinal data. The second metamagnetic transition was out of the available field range but is clearly visible at slightly higher
Figure 1: (a) High field magnetization of UIrGe at 4.2 K. The $a$-axis magnetization is linear while for $B // b$ and $c$ axis, a step-like metamagnetic transition appears at about 12.3 T and 20 T, respectively. A slight change in slope may be discerned at about 18 T for $B // b$ axis and about 13 T for $B // c$ axis. (b) A comparison of longitudinal and transverse magnetoresistance of UIrGe at 8 K. Both curves exhibit two metamagnetic transitions but the relative magnitudes of the responses are inverted in going from the longitudinal to the transverse configurations. The inset of (b) shows the temperature dependence of the resistivity of UIrGe at 18 T. The sharp upturn in the low-temperature resistivity, indicative of an antiferromagnetic super-zone gap, is suppressed in the longitudinal configuration.

temperatures. Figure 1(b) shows the magnetoresistance at 8 K. Here, a small step in the magnetoresistance around 12 T is followed by a drastic fall around 16.5 T to less than 50% of the zero field value. This is, in some sense, inverse of the longitudinal configuration case, in which a pronounced drop in the magnetoresistance was followed by a much weaker transition at higher fields. In temperature scans at fixed fields, the resistivity increases below $T_N \approx 14.4$ K and the transition moves to lower temperatures with increasing applied fields, in good agreement with measurements taken in the longitudinal configuration. The inset of Figure 1(b) shows the temperature dependence of the resistivity in a field of 18 T applied along the $c$ axis. Unlike the data taken in the longitudinal configuration, the upturn in low temperature resistivity, which is believed to be connected to an opening of an antiferromagnetic gap in the Fermi surface, is not suppressed by application of a field up to 18 T. Furthermore, we observed only one clear anomaly in the temperature scans, whereas data taken in the longitudinal configuration showed two transitions in the fixed field range of 11 – 13 T (see Ref. [10]).

To summarize, we have measured the high-field magnetization of UIrGe in fields up to 38 T applied along the principle axes and extended our previous magnetoresistance studies to measurements in the transverse configuration for fields applied along the $c$ axis. We observed substantial differences between the two sets of magnetoresistance data (transverse and longitudinal configurations), which
suggests a highly anisotropic Fermi surface in UIrGe. In addition, given that only one metamagnetic transition appears clearly in the magnetization curves, one may speculate that only one of the metamagnetic transitions involves a change in the magnetic structure. However, an unambiguous description of even the zero-field structure has still not been established. Clearly, a microscopic determination of the magnetic structures is necessary to clarify the nature of the transitions in UIrGe.

Acknowledgments

This work was supported by a grant from NSF (grant number: DMR-0094241). Work at the National High Magnetic Field Laboratory in Los Alamos was performed under the auspices of the NSF (INT-9722777), the US Department of Energy and the State of Florida.

References

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