Magnetic Field-Angle Study of $CePb_3$

P.M.C. Rourke (U. of Toronto, Physics); S.E. Sebastian (U. of Cambridge, Cavendish Lab.);
S.R. Julian (U. of Toronto, Physics)

Introduction

$CePb_3$ is a cubic heavy-fermion antiferromagnet with a zero-field, ambient pressure Néel transition at T_N = 1.1 K, leading to an incommensurate magnetic structure [1]. Below the Néel temperature, previous studies observed a field-induced transition at 5 T for fields directed along the crystallographic (110) direction, but not for fields along (100); a second transition was detected at 9.5 T for all fields in the (110)-(100) plane. These transitions indicate a jump from the antiferromagnetic phase to a "spin-flop" canted-moment phase at 5 T, when fields are directed along the magnetic hard (110) rather than easy (100) axis, before reaching the high-field ferromagnetically-polarized phase at 9.5 T [2].

Experimental

Single crystal samples of $CePb_3$ were prepared via flux growth, and handled under a helium atmosphere. At the National High Magnetic Field Laboratory in Tallahassee, the samples were mounted on a top-loading dilution refrigerator rotation stage. Electrical resistivity, ac susceptibility and cantilever torque magnetometry experiments were conducted as a function of temperature, magnetic field strength and field angle in the SCM 1 18/20 T superconducting magnet.

Results and Discussion

In agreement with previous results [2], our resistivity measurements for fields in the (110)-(100) plane found a large increase in the magnetoresistance at low fields, followed by a rapid decrease at the 5 T (110) spin-flop transition and a further gentle decrease to a constant value at fields above 9.5 T. For fields along (111), a magnetically-"harder" direction than (110) that had not been previously studied, the 5 T and 9.5 T transitions merge into a single magnetoresistance drop at 6 T. Temperature-dependence of the resistivity revealed an anomaly in the T^2 coefficient at this 6 T transition.

Our ac susceptibility measurements showed a slowly-varying, field-dependent background, in agreement with the literature [3], but without sharp features to coincide with the field-induced transitions. In the context of the magnetic character of this material and pronounced field-dependence of the magnetoresistance, the lack of strong features in the susceptibility is notable. Our torque measurements, the first of their kind on $CePb_3$, uncovered a torque signal that changed sign several times as a function of field strength, particularly for fields along (111), and was very sensitive to the field angle.

A computer spin model containing appropriate magnetocrystalline anisotropy reproduced the spin-flop phase transition and torque sign changes. However, in contrast with experiment, the model predicts that the spin-flop transition is first order.

Conclusions

Our experiments show that the strongest spin-flop transition in $CePb_3$ occurs with the field along (111). Disagreement between the measurements and our model with respect to transition sharpness and (lack of) ac susceptibility features indicate that this spin-flop transition is not fully understood, likely due to Kondo screening; this will be the focus of future studies.

Acknowledgements

Funding provided by the Natural Sciences and Engineering Research Council of Canada, the Canada Foundation for Innovation, and the Canadian Institute for Advanced Research.

References

[1] Vettier, C., *et al.*, Physical Review Letters, **56**, 1980-1983 (1986).
[2] McDonough, J., *et al*., Physical Review B, **53**, 14411-14414 (1996).
[3] Ebihara, T., *et al*., Physical Review B, **61**, 2513-2520 (2000).