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PRESSURE EMERGENCE OF MAGNETIC ORDERING IN UBe_{13}

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The electrical resistivity and the thermopower of UBe_{13} have been measured between 1.2 and 300 K at pressures up to 67 kbar and in magnetic fields up to 6 T. While the resistivity reflects the partial delocalization of the f resonance, the marked oscillation of the low temperature thermopower strongly suggests that pressure drives a magnetic order well above T_c.

1. Introduction

Usually the transport properties of heavy fermion compounds (HFC) are described by independent Kondo like scattering at high temperature ($T \gg T_K$) and in terms of a coherence effect at low temperature ($T \lesssim T_K$). In UBe_{13}, unlike other heavy electron superconductors, coherence scattering is still not developed when superconductivity arises at $T_c \sim 0.9$ K.

Indeed the resistivity ρ is still very large just above T_c, and the thermopower Q has not even reached its negative peaks [1]. To observe the low T excitations of the normal phase, high pressure transport experiments under magnetic field were performed. Pressure was generated by a pair of opposed Bridgman anvils made of non-magnetic tungsten carbide.

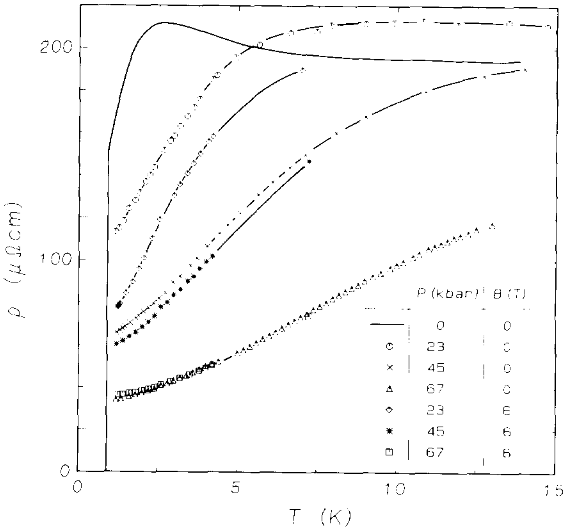

Fig. 1. Resistivity of UBe_{13} at different pressures in magnetic fields of 0 and 6 T.

2. Resistivity

Low temperature results of resistivity ρ are presented in fig. 1. The pressure delocalization of the f resonance induces the strong depression of ρ and the increase of the temperature T^{ρ}_{max} of its maximum value, in good agreement with refs. [2] and [3]. A resistivity behavior rather similar to UPt_3, i.e. without resistivity maximum, is expected at about 200 kbar.

At low pressure, the large and negative magnetoresistance $\Delta\rho/\rho$ is characteristic for the presence of local magnetic moments. At intermediate pressure ($P = 45$ kbar) $\Delta\rho/\rho$ is still negative but weaker and at high pressure ($P = 67$ kbar) $\Delta\rho/\rho$ is slightly positive below 4 K. Such a positive magnetoresistance has been observed in moderate HFC like UPt_3, $CeRu_2Si_2$ or $CeAl_3$ under pressure [4].

At 67 kbar, preliminary data do not show any superconducting transition down to 0.1 K and above 1.2 K, the T^2 law of ρ is still not recovered.

At $P = 0$, for a sample from the same batch, a residual resistivity $\rho_0 \sim 12$ $\mu\Omega$cm has been measured at $B = 12$ T [5]. Our results then suggest a maximum of ρ_0 near 45 kbar.

3. Thermopower

As often observed in HFC, the thermopower Q of UBe_{13} is positive at high temperature and takes large negative values at low temperature. Fig. 2 shows that the negative peak of Q, centered at T^{Q}_{min}, emerges above T_c under pressure. The clear correlation of T^{Q}_{min} with T^{ρ}_{max} asserts the same physical origin. The pressure independence of the magnitude of $Q(T^{Q}_{min})$ agrees with a P increase of the width of the f resonance.

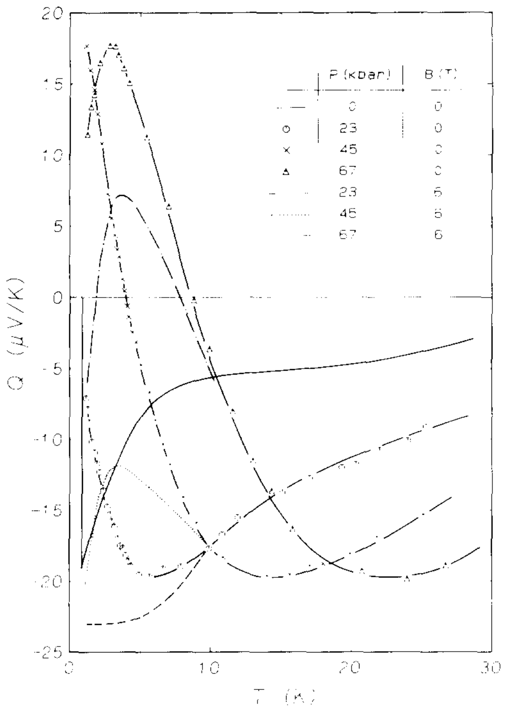

Fig. 2. Absolute thermopower of UBe_{13} at different pressures in magnetic fields of 0 and 6 T.

The most interesting feature in fig. 2 is the low T positive contribution of Q which is clearly resolved at 67 kbar. We claim that such a peak is the signature of an antiferromagnetic order. If a magnetic gap opens only in parts of the Fermi surface, it may be possible that no corresponding anomaly occurs in the resistivity. Large positive peaks of Q have been observed for well characterized antiferromagnets like UCu_5 [6], TmSe or TmS [7]. In these cases the change of sign of Q corresponds to the ordering temperature T_N. The recently discovered antiferromagnet UPt_3 ($T_N \sim 5$ K) with a very low ordered moment also shows a positive peak of Q at ~ 8 K and a change of sign at ~ 24 K [8]. This thermoelectric behavior is expected for UBe_{13} at roughly 200 kbar, i.e. the same pressure estimated from the resistivity.

From our previous study at $P = 0$ [1], a positive peak of Q can be extrapolated at $T \sim 150$ mK. A specific heat anomaly was recently discovered at the same temperature [5]. So it appears that the magnetic ordering sets in above T_c under pressure.

The highly magnetic field dependence of the low T thermopower is another evidence of its magnetic origin (fig. 2). As P increases, increasing fields are needed to destroy the positive contribution.

4. Conclusion

As pressure certainly induces the decrease of the low temperature electronic specific heat coefficient per unit volume γ_v, our results illustrate the correlation which has been found at zero pressure between γ_v and the ground state configuration of uranium based HFC [9]. It is not so surprising that at high pressure UBe_{13} behaves rather like the antiferromagnetically ordered HFC UCu_5 or UPt_3.

References

[1] D. Jaccard, J. Flouquet, Z. Fisk, J.L. Smith and H.R. Ott, J. Phys. Lett. 46 (1985) L811.

[2] J.D. Thompson, M.W. McElfresh, J.O. Willis, Z. Fisk, J.L. Smith and M.B. Maple, Phys. Rev. B 35 (1987) 48.

[3] Z. Fisk et al., Intern. Conf. HTSC, Interlaken (1988).

[4] Ch. Fierz, D. Jaccard, J. Sierro and J. Flouquet, J. Appl. Phys. 63 (1988) 3899.

[5] J.P. Brison, to be published.

[6] H.J. van Daal, K.H.J. Buschow, P.P. van Aken and M.H. van Maaren, Phys. Rev. Lett. 34 (1975) 1457.

[7] D. Jaccard and J. Sierro, Solid State Commun. 31 (1979) 713.

[8] J.J.M. Franse et al., Z. Phys. B 59 (1985) 15.

[9] Z. Fisk et al., Science 239 (1988) 33.