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LOW TEMPERATURE MEASUREMENTS ON UBe_{13}

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Transport and specific heat measurements are reported on a new sample of UBe_{13}. Special focuses are given on the zero field specific heat : at low temperature (T < 150 mK) where the impurity scattering dominates, at intermediate temperature where a quasi T^3 law characteristic of an axial state is obeyed and near the critical temperature where critical fluctuations are observed. Correlations are made with magnetoresistivity and thermal conductivity experiments.

The purity of materials is crucial for the low temperature behavior of heavy fermion superconducting compounds (HFC) (1). We report extensive experiments on a sample of UBe_{13} characterized by transport (resistivity (ρ), and thermal conductivity (K)) and specific heat (C) measurements. The experimental methods are given in references (2) and (3). Transport experiments are performed down to 40 mK in field H up to 12 T. The specific heat is measured down to 38 mK ; these measurements are actually extended in magnetic fields. The different samples are taken from a batch referred as (a).

The curve (1) represents the low temperature behavior of C/T. The relative sharpness of the superconducting transition by comparison to different published data is a first indication of the quality of the material (4,5). This statement is reinforced by the magnetoresistivity study. As previously made for experiments performed (6) on another batch referred as (b), below 900 mK, the resistivity at constant magnetic field is decomposed by the sum of two terms :

$$\rho(T) = \rho_o(H) + A_H T^2.$$

They represent respectively a residual contribution characteristic of impurity effects and a quadratic temperature dependence which may have an intrinsic origin. As shown by figure (2), $\rho_o(H)$ drops by a factor 3 (almost field independent) from sample (b) to (a), while A_H decreases only by a factor 1.3. The extrapolated high field residual resistivity $\rho_o(H) \cong 12$ $\mu\Omega$cm is yet the lowest already reported.

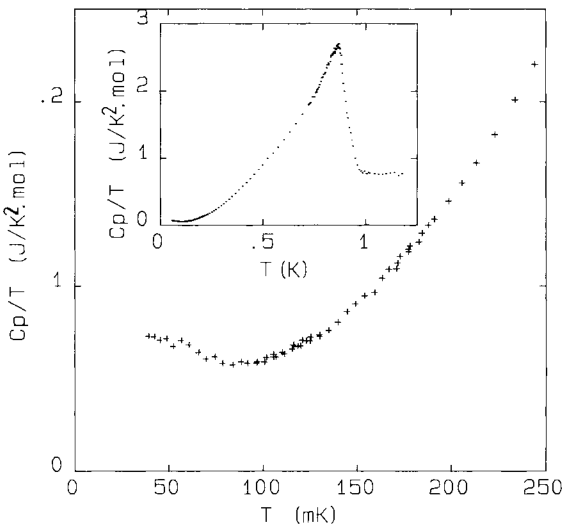

Figure 1 : variation of C/T at low temperature, insert the same dependence up to 1.2 K.

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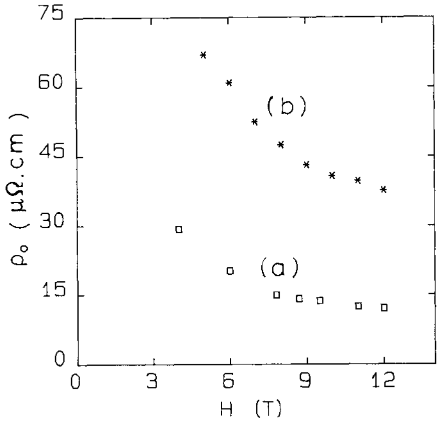

Figure 2 : Field variation of $\rho_o(H)$.

Let us focus on the temperature dependence of C. It must be noticed that a fit by a T^3 law is hardly achieved even at intermediate temperature (150 mK - 500 mK). Thus in this temperature range it is not obvious to claim that the ground state of UBe_{13} is an axial superconducting state. At low temperature (T < 150 mK), a strong impurity scattering will dominate (1,7,8,9). It must be emphasized that down to 150 mK no γT can be extrapolated in C/T at T $\rightarrow$ 0 K. That precludes to invoke an incomplet superconducting transition of the sample. The main feature is the occurrence of a minimum of C/T at 90 mK with an apparent saturation below 60 mK. The detection of a residual linear temperature term in C/T on different samples with different amplitudes indicates already clearly their extrinsic origin (3). The probable occurrence of a vanishing gap energy on points or lines at the Fermi surface (see 5) leads to an unusual high sensitivity to defect notably if impurities are characterized by a phase shift $\delta_F = \pi/2$ at the Fermi energy. Such a situation seems to be realized in UBe_{13} as a strong negative residual magnetoresistivity is observed. Here the amount of impurities is low enough for observing one additionnal resonance in the unperturbed density of state as predicted theoretically (7). For high content of impurities a gapless Abrikosov Gorkov superconductor will emerge : the minimum of C/T will collapse. Thermal conductivity experiments show in this sample of good quality no signature of a residual linear T term. This complementary observation is in excellent agreement with the theoretical calculation (7) of K showing that for a low content of impurities, the dominant effect is the decrease of the mean free path. The low temperature T^3 dependence of K when $\delta F = \pi/2$ may support the idea of an axial state however the discussion on the thermal conductivity data needs a carefull substraction of the phonon contribution which is high at 4.2 K and still almost 50 percent of the total thermal conductivity at T_c.

Finally let us remark that C/T has a positive up turn on approaching T_c from the low temperature superconducting state. That may reflect the unusual importance of critical fluctuation connected with the weak value of the coherence length. Preliminary field measurements of C show a drastic change not only at the low temperature but also in the intermediate temperature range where the quasi T^3 dependence changes to a T^2 contribution. That indicates that magnetic field may probe crucially the pairing of the superconducting state.

REFERENCES

(1) C.J. Pethick and D. Pines, Phys. Rev. Lett. 57 (1986) 118.
(2) D. Jaccard, J. Flouquet, Z. Fisk, J.L. Smith and H.R. Ott, J. Physique Lett. 46 (1985) L811.
(3) A. Ravex, J. FLouquet, J.L. Tholence D. Jaccard and A. Meyer, J. Magn. Magn. Mat. 63-64 (1987) 400.
(4) N.E. Phillips, J. Magn. Magn. Mat. 63-64 332 (1987)
(5) H.R. Ott, Physica 148B (1987) 400.
(6) G. Remenyi, D. Jaccard, J. Flouquet, Z. Fisk, J.L. Smith and H.R. Ott, J. Phys. 47 367 (1986).
(7) P. Hirshfeld, D. Vollhardt and P. Wölfe, Solid State Commun. 59 (1986) 111.
(8) S. Schmitt-Rink, K. Miyake and C.M. Varma, Phys. Rev. Lett. 57 (1986) 2575.
(9) H.R. Ott, E. Felder, C. Bruder and T.M. Rice, Europhys. Lett. 3 (1987) 1123.