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FIELD DEPENDENCE OF THE SPECIFIC HEAT OF UBe_{13}

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Specific heat (C) measurements in magnetic field (H) up to 8 T show drastic changes below the superconducting transition in contrast to the H independent value of C/T in the normal phase. It is suggested that the normal phase may undergo magnetic order at $T \sim 150$ mK.

Recent specific heat (C) measurements performed in zero field on UBe_{13} down to 38 mK show that: i) the critical fluctuations are large near T_c; ii) a quasi T^3 law is observed only between 150 and 500 mK and iii) the low temperature behavior is dominated by strong impurity effects [1]. We will focus here on the magnetic field (H) dependence of the specific heat. The measurements were made by a relaxation method.

The curves of fig. 1 show, as previously reported that the specific heat of the normal phase is independent of H [2]. In agreement with the Maxwell relation, the magnetization is found below 4 K as weakly temperature dependent [3]. By contrast, the specific heat of the superconducting phase changes drastically with H. For example, the T^3 law, observed at $H = 0$ for 150 mK $< T <$ 500 mK, is no more obeyed. For the applied fields (1.89/3.92/5.8 T), the power laws of C are close to:

$$C = \alpha T + \beta T^2.$$

The decomposition of normal and superconducting contribution appears difficult: no simple linear field dependence of the αT is observed. This may be due to the fact that the vortices of an anisotropic superconducting state are not so simple as in isotropic superconductors and also that the condensation energy of the superconducting state may be strongly H dependent [4]. It is intriguing to mention that the T^2 law of C is generally taken as a proof of polar superconducting states

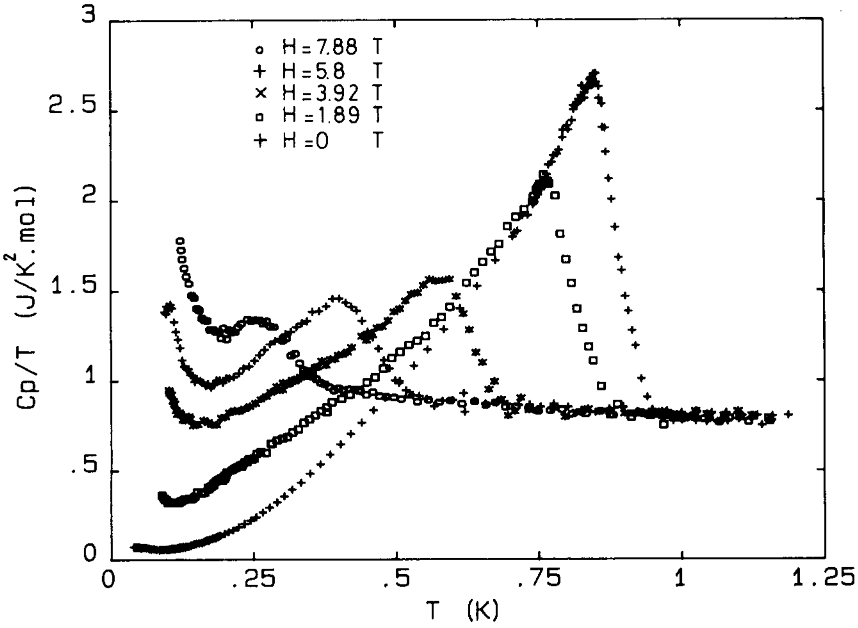

Fig. 1. Temperature variation of the specific heat at different applied fields.

and that the observed T^3 law observed for the nuclear relaxation time (characteristic of a polar state) [5] cannot be reconciled with the T^3 law observed on the specific heat at $H = 0$ (characteristic of an axial state) [6]. A better understanding of the role of the vortices is clearly needed.

Let us now focus on the low temperature behavior ($T < 150$ mK), and notably on the large rising of C/T on cooling with H. By the relaxation method, only the electronic contribution is usually measured due to the large difference between electronic and nuclear relaxation time. An important experimental new feature is a distorsion of the exponential decay of the temperature of the sample after heat pulses which coincides with the C/T rise. We have carefully checked that such an increase of C/T is necessary to respect the entropy balence i.e. a linear extrapolation of C/T below 150 mK leads to an insufficient superconducting entropy. Clearly, the upturn of C/T below 150 mK has an intrinsic origin. For $H = 6$ T, the measurements were extended down to 95 mK; C/T goes through a maximum at 105 mK. Such a maximum is also necessary to conserve entropy.

Thus, in magnetic field, a second transition appears after the superconducting one. It could be attributed to a new superconducting phase however there are arguments favoring the occurrence of a magnetic transition in the induced normal state. Entropy balance in zero field shows that C/T in the normal phase must increase on cooling [2,6]: so it is quite natural to recover a rising of C/T at constant field as the induced vortices gradually restore the contribution of the excitations of the normal phase to C. The distorsion of the exponential relaxation of T appears on a time scale of a tenth of seconds, much shorter than the 500 seconds which can be extrapolated from NMR data [5] at $H = 6$ T. This drastic change indicates a modification in the vortices since their excitations dominate the nuclear relaxation rate [5].

If superconductivity does not occur, UBe_{13} will be magnetically ordered at $T \sim 150$ mK in $H = 0$. Applying H allows to observe the magnetic phase of UBe_{13}. The critical magnetic field $H_M(T)$ must be lower than the upper critical superconducting field found equal to 13.9 T since no field anomaly is observed on the magnetoresistivity. Elastic neutron scattering experiments should provide an unambiguous answer to this proposal.

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