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SPECIFIC HEAT OF HEAVY FERMION SUPERCONDUCTORS UNDER PRESSURE

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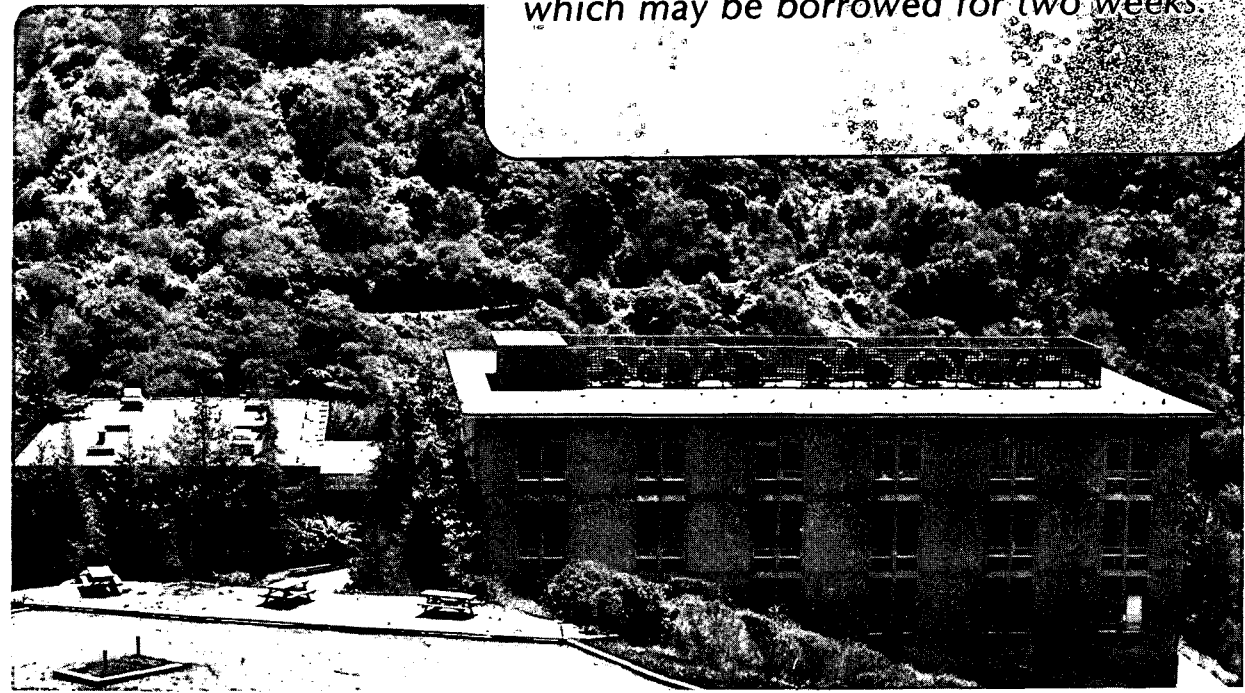
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UNDER PRESSURE

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UNDER PRESSURE

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Abstract: We have performed high precision measurements of the specific heats of  $UPt_3$  and  $UBe_{13}$  between 0.4 and 20 K for pressures up to 9.3 kbar.

The specific heat of  $UPt_3$  above the superconducting transition temperature,  $T_c$ , at zero pressure can<sup>1,2</sup> be fit to

$$C = \gamma T + \beta T^3 + \delta T^3 \ln T / T_{SF} \quad (1)$$

where  $\gamma$  is proportional to the bare density of states at the Fermi energy,  $N(0)$ , times an enhancement factor  $(1 + \lambda)$ ,  $\beta = \frac{1}{3}$  (with  $\theta_D \equiv$  Debye temperature), and  $T_{SF}$  is the spin fluctuation temperature. Depending on the assumptions one makes, including that for  $\theta_D = f(T)$ , one obtains<sup>3,4</sup>  $T_{SF} = 26 - 60$  K. One can also fit specific heat data under pressure to eq. 1 above and, keeping the assumptions constant, obtain qualitatively the behavior of the spin fluctuation temperature with pressure. The result<sup>4</sup> is that  $T_{SF}$  increases by over 40% as pressures increase to 9 kbar. This is qualitatively consistent with the observation that the upturn observed<sup>2-4</sup> in the  $C/T$  versus  $T^2$  plot of the data at low temperatures ( $T < 8$  K) which is associated with the spin fluctuations becomes weaker and almost disappears with increasing pressure, i.e. as the paramagnons become stiffer ( $T_{SF}$  increases), then their contribution to the specific heat at low temperatures is decreased.

The other parameter of interest for these  $C(P)$  measurements on  $U\text{Pt}_3$  is the response of  $\gamma$  to pressure. The results are as follows, with  $\gamma$  in units of  $\text{mJ}/\text{mole}\cdot\text{K}^2$ :  $P = 0$ ,  $\gamma = 426$ ;  $P = 3.8$  kbar,  $\gamma = 384$ ; and  $P = 8.9$  kbar,  $\gamma = 334$ . There is therefore a 22% decrease in  $\gamma$  with 8.9 kbar pressure. This compares to a<sup>5</sup> 30% decrease in  $\gamma$  for  $\text{UBe}_{13}$  at 9 kbar and a<sup>6</sup> 35% decrease in  $\gamma$  for  $\text{CeCu}_2\text{Si}_2$  at 6 kbar. Clearly then, all the highly-correlated-electron superconductors have this rapid decrease of  $\gamma$  with pressure in common. It is interesting to note that  $\gamma$  for  $\text{YbCuAl}$  goes up<sup>7</sup> with pressure (from 220 at  $P = 0$  to 335  $\text{mJ}/\text{mole}\cdot\text{K}^2$  at  $P = 8.3$  kbar,) while  $\gamma$  for the non-superconducting heavy fermion compound  $\text{CeAl}_3$  decreases<sup>8</sup> from 1200  $\text{mJ}/\text{mole}\cdot\text{K}^2$  at  $P = 0$  to 549  $\text{mJ}/\text{mole}\cdot\text{K}^2$  at  $P = 8.2$  kbar (an over 50% decrease). Thus, without further (theoretical) insight into the mechanism of heavy fermion superconductivity, the observed correlation in the three heavy fermion superconductors ( $\Delta\gamma$  is large and negative with pressure) can be considered as interesting but, considering the  $\text{CeAl}_3$  result, not necessarily of significance.

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1. G. R. Stewart, Z. Fisk, J. O. Willis, and J. L. Smith, *Phys. Rev. Lett.* 52, 679 (1984).
  2. A. de Visser, J. J. M. Franse, A. Menovsky, and T. T. M. Palstra, *J. Phys.* F14, L191 (1984).
  3. J. J. M. Franse, A. de Visser, A. Menovsky, and P. H. Frings, *J. Magn. Magn. Mat.* 52, 61 (1985).
  4. G. E. Brodale, R. A. Fisher, N. E. Phillips, G. R. Stewart, and A. L. Giorgi, to be published.

5. J. A. Olsen, R. A. Fisher, N. E. Phillips, G. R. Stewart, and A. L. Giorgi, Bull. Am. Phys. Soc. 31, 648 (1986), and to be published.
6. A. Bleckwedel and A. Eichler, Sol. St. Comm. 56, 693 (1985).
7. A. Bleckwedel, A. Eichler, and R. Pott, Physica 107B, 93 (1981).
8. G. E. Brodale, R. A. Fisher, N. E. Phillips, and J. Flouquet, Phys. Rev. Lett. 56, 390 (1986).

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