Title
SPECIFIC HEAT OF HEAVY FERMION SUPERCONDUCTORS UNDER PRESSURE

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Publication Date
1986-05-01

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Presented at the 2nd Workshop on Actinides under Pressure, Karlsruhe, West Germany, June 2-3, 1986; and to be published in Physica B

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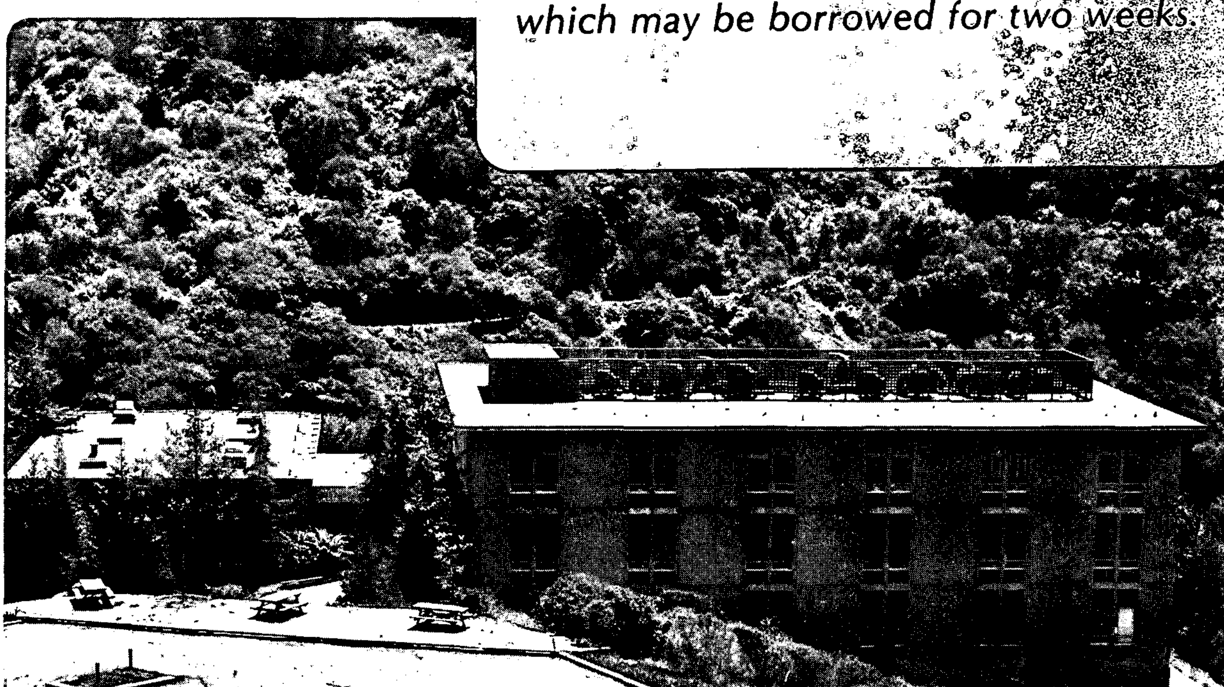

Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

DISCLAIMER

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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[1,2] be fit to

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

where γ is proportional to the bare density of states at the Fermi energy, N(0), times an enhancement factor $(1 + \lambda)$, $\beta \propto \frac{1}{\Theta_D^3}$ (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[3,4] $T_{SF} = 26 - 60$ 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[4] 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[2-4] 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 UPt_3 is the response of γ to pressure. The results are as follows, with γ in units of $mJ/mole\text{-}K^2$: P = 0, γ = 426; P = 3.8 kbar, γ = 384; and P = 8.9 kbar, γ = 334. There is therefore a 22% decrease in γ with 8.9 kbar pressure. This compares to a[5] 30% decrease in γ for UBe_{13} at 9 kbar and a[6] 35% decrease in γ for $CeCu_2Si_2$ at 6 kbar. Clearly then, all the highly-correlated-electron superconductors have this rapid decrease of γ with pressure in common. It is interesting to note that γ for YbCuAl goes <u>up</u>[7] with pressure (from 220 at P = 0 to 335 $mJ/mole\text{-}K^2$ at P = 8.3 kbar,) while γ for the non-superconducting heavy fermion compound $CeAl_3$ decreases[8] from 1200 $mJ/mole\text{-}K^2$ at P = 0 to 549 $mJ/mole\text{-}K^2$ 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 $CeAl_3$ result, not necessarily of significance.

The work at Berkeley was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Sciences Division of the U. S. Department of Energy under Contract No. DE-AC03-76SF00098.

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