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SPECIFIC HEAT OF (Ce, La) Ru₂Si₂ AT HIGH MAGNETIC FIELDS

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Abstract. - Specific heat (C) measurements on Ce₁₋ₓLaₓRu₂Si₂ were made in order to observe the change in C on going from a long range magnetically ordered system (x ≥ 0.08) to a paramagnetic system. Magnetic field measurements of C show that a maximum of the effective mass occurs at the metamagnetic-like transition.

The compound CeRu₂Si₂ exhibits interesting magnetic features [1]. Its magnetization for H parallel to the tetragonal c-axis (M) displays a metamagnetic-like transition at Hₘ ≈ 8 T, although no long range magnetic order could be detected. This field corresponds to the quenching of the antiferromagnetic (AF) correlations occurring below 60 K [2]. In reference [1] it was argued by comparing the temperature dependencies of the resistivity at various fields that the electronic effective mass m* would go through a maximum at Hₘ. In order to check this suggestion, we have performed specific heat measurements on single crystals of Ce₁₋ₓLaₓRu₂Si₂ (x = 0, 0.05, 0.10 and 0.13). Substituting La for Ce reduces Hₘ [3] and induces antiferromagnetic (AF) order for x ≥ 0.08 [4]. The corresponding critical fields are respectively 7.9, 5.7, 3.8, 3.65 T at ≈ 1.4 K (i.e. below Tₙ for the two last systems) [3]. For H = 0, the measurements extended from ≈ 0.1 K to ≈ 30 K. Magnetic fields up to 7.5 T were applied along the c-direction for T ≥ 0.4 K.

The H = 0 data are displayed as C vs. T (up to 16 K) in figure 1a; figure 1b shows C/T vs. T up to 9 K. These data are consistent with previous results for polycrystals [5]. The value of C/T extrapolated to T = 0 (γ₀) increases from 360 mJ mol⁻¹ K⁻² for x = 0 to 585 mJ mol⁻¹ K⁻² for x = 0.1 and then decreases again. γ₀ may reach a critical value γ₀c ≈ 600 mJ mol⁻¹ K⁻² at the magnetic - non magnetic (M-NM) transition which occurs near x = 0.08 as shown by neutron diffraction experiments [4]. Indeed, for x = 0.13, AF ordering leads to a peak in C at Tₙ = 3.8 K. This anomaly is very similar to that reported [6] for CePb₃, a typical long range magnetically ordered heavy fermion compound. Although no peak in C(T) is observed for x = 0.1, it is worth noticing the similarity between the x = 0.1 and x = 0.13 data in the C/T representation, i.e. a sharp increase on cooling followed by an almost flattening (see Fig. 1b). This suggests that our x = 0.1 crystal orders below

Fig. 1. - Specific heat of single crystals of Ce₁₋ₓLaₓRu₂Si₂. a) as C vs. T: (●) x = 0, (○) x = 0.05, (♦) x = 0.1 and (▲) x = 0.13; b) as C/T vs. T below 9 K.

≈ 2.5 K which is consistent with Tₙ = 2.7 K determined by neutron experiments [4]. On the non magnetic side of the M-NM transition (x = 0 and 0.05), the smooth increase of C/T on cooling is very similar to that reported [7] for CeCu₄.

Figure 2 shows the field dependence of γ₀. A clear increase of γ₀ towards Hₘ is observed for the two NM compounds. For x = 0.05 for which it was possible to perform experiments well above Hₘ, γ₀ (H) goes through a maximum at a field of ≈ 5.5 T, consistent with the value of Hₘ derived from magnetization data [3]. While γ₀ = 500 mJ mol⁻¹ K⁻² at H = 0, γ₀ (Hₘ) = 655 mJ mol⁻¹ K⁻²: an increase of 30 %. Magnetization experiments at 1.5 K lead to an increase of the differential susceptibility χ = ∂M/∂H by a factor of 2.7 at Hₘ. Such a dependence of γ₀ with H stresses the importance of the magnetic correlations [1, 2]. γ₀ (Hₘ) = 655 mJ mol⁻¹ K⁻² is roughly the same value as the critical value γ₀c defined above, which suggests that this critical magnitude of γ₀ drives the

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magnetic instabilities induced either by $H$ or by addition of La.

No maximum in $\gamma_0(H)$ can be seen for $x = 0.1$. This may be due to the fact that $\gamma_0$ is already very close to $\gamma_0c$. However, the occurrence of a new feature (the existence of maxima in the $C/T$ vs. $T$ curves in magnetic fields, connected to the crossing of lines of the ($H$, $T$) magnetic phase diagram [3]) prevents accurate extrapolations of $C/T$ to $T = 0$, making measurements at lower temperatures desirable.

Finally, $\gamma_0(H)$ decreases rapidly with $H$ above $H_M$ where high magnetic polarization is achieved. Further studies of these polarized phases will lead to a better understanding of the heavy fermion compounds.

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