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DISCLAIMER

SPECIFIC HEAT OF $(Ce,La)Ru_2Si_2$ IN HIGH MAGNETIC FIELDS

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ABSTRACT

Specific heat (C) measurements on $Ce_{1-x}La_xRu_2Si_2$ were made in order to observe the change in C on going from a long range magnetically ordered system ($x \geq 0.07$) to a paramagnetic system. Magnetic field measurements of C show that a maximum of the effective mass occurs at the metamagnetic-like transition.

Keywords

High field, specific heat, effective mass enhancement, heavy fermion

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The compound $CeRu_2Si_2$ exhibits interesting magnetic features [1]. Its magnetization (M) for H parallel to the tetragonal c-axis displays a metamagnetic-like transition at $H_M \approx 8T$, although no long range magnetic order could be detected. This field corresponds to the quenching of the antiferromagnetic (AF) correlations occurring below 60K [2]. In Ref. 1, it was argued by comparing the temperature dependences of the resistivity at various fields that the electronic effective mass m* would go through a maximum at H_M. In order to check this suggestion, we have made specific heat measurements on single crystals of $Ce_{1-x}La_xRu_2Si_2$ (x=0, 0.05, 0.10 and 0.13). Substituting La for Ce reduces H_M [3] and induces AF order for x≥0.08 [4]. The corresponding critical fields are respectively 7.9, 5.7, 3.8 and 3.65T at ≈1.4K (i.e., below T_N for the two last systems) [3]. For H=0, the measurements extended from ~0.1K to ~27K. Magnetic fields up to 7.5T were applied along the c-direction for T≥0.4K.

The H=0 data are displayed in Fig. 1; the inset shows the low temperature region as C/T vs. T. They are consistent with previous results for polycrystals [5]. The value of C/T extapolated to T=0(γ_o) 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. γ_o may reach a critical value γ_{oc} ~ 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 T_N=3.8K. This anomaly is very similar to that reported [6] for $CePb_3$, 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 followed by an almost flattening (see Fig. 1 inset). This suggests that our x=0.1 crystal orders below ~2.5K which is consistent with T_N=2.7K 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 $CeCu_6$.

Fig. 2 shows the field dependence of γ_o. A clear increase of γ_o towards H_M is observed for the two NM compounds. For x=0.05 for which it was possible to perform experiments well above H_M, γ_o(H) goes through a maximum at a field of ~5.5T, consistent with the value of H_M derived from magnetization data [3]. While γ_o=500 mJ $mol^{-1}K^{-2}$ at H=0, $\gamma_o(H_M)$=655 mJ $mole^{-1}K^{-2}$: an increase of 30%.

Magnetization experiments at 1.5K lead to an increase of the differential susceptibility ($\chi=\partial M/\partial H$) by a factor of 2.7 at H_M. Such a dependence of γ_{oc} with H stresses the importance of the magnetic correlations [1,2]. $\gamma_o(H_M)=655$ mJ $mol^{-1}K^{-2}$ is roughly the same value as the critical value γ_{oc} defined above, which suggests that this critical magnitude of γ_o drives the magnetic instabilities induced either by H or by addition of La.

No maximum in $\gamma_o(H)$ can be seen for x=0.1. This may be due to the fact that γ_o is already very close to γ_{oc}. 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, $\gamma_o(H)$ 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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Figure Captions

Fig. 1. Specific heat of $Ce_{1-x}La_xRu_2Si_2$. The insert shows C/T vs T.

Fig. 2. Field variation of C/T extrapolated to T=0K.

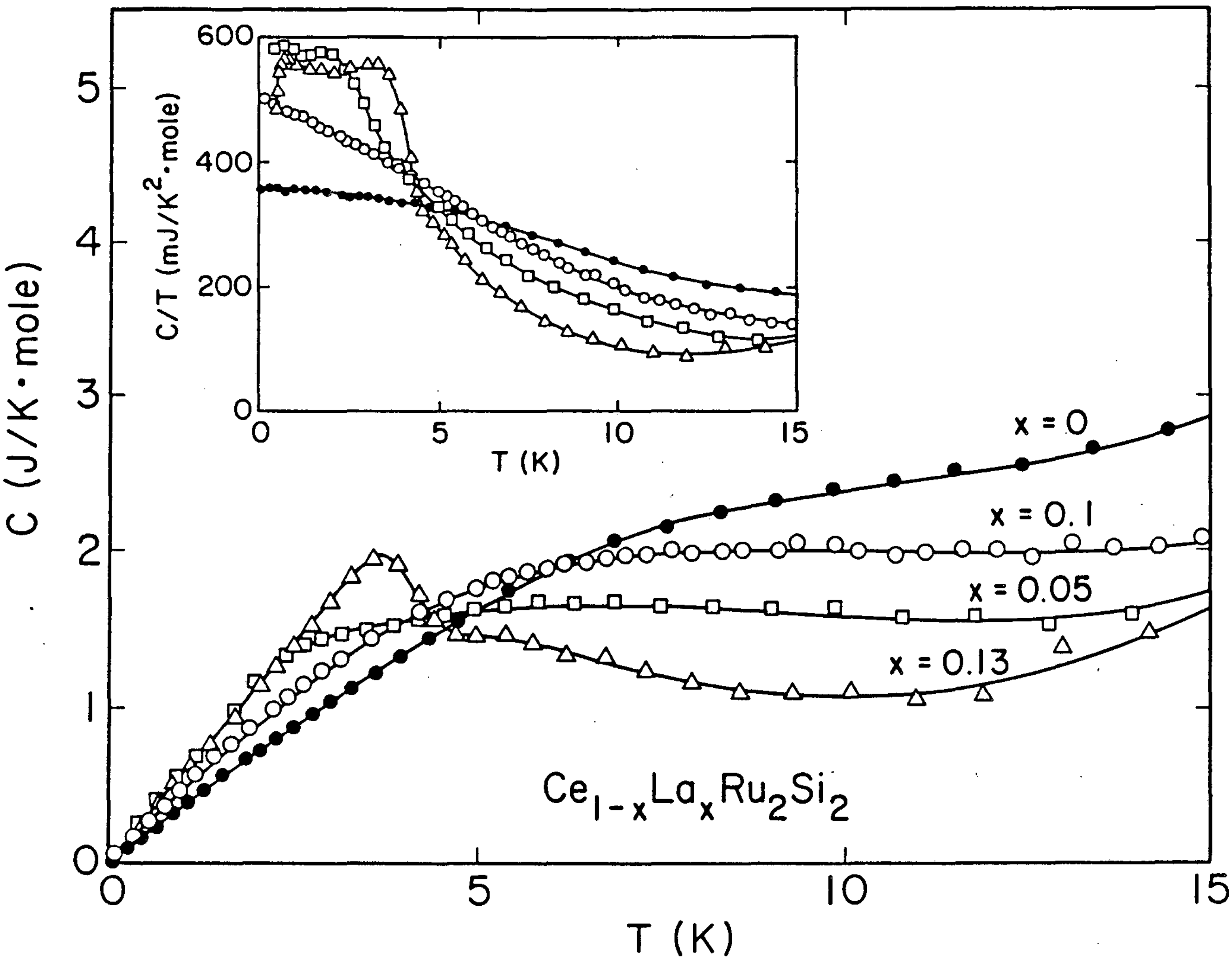

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Fig. 1

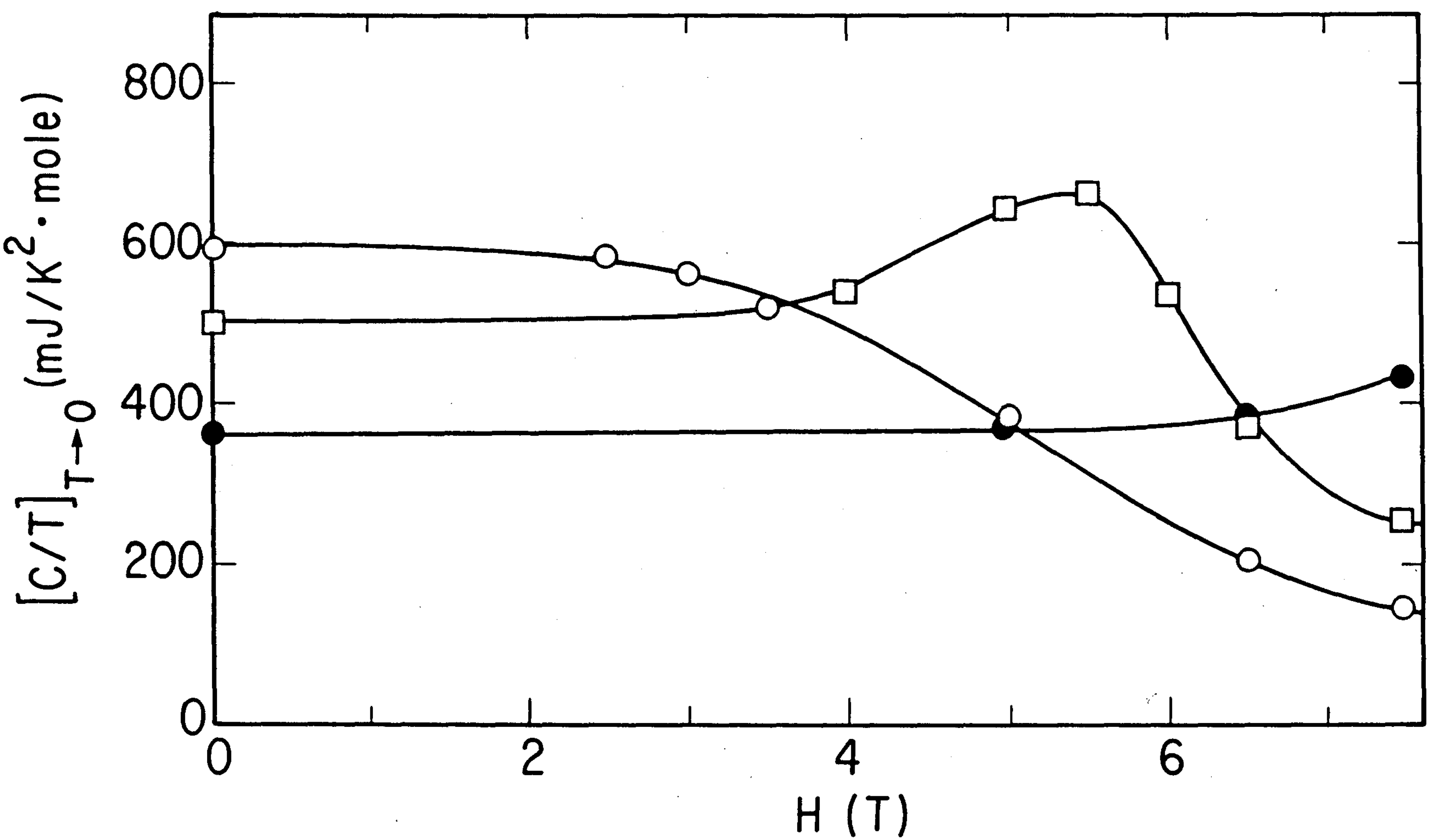

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Fig. 2