GIANT ENHANCEMENT OF THE *T*-LINEAR SPECIFIC HEAT IN R_3T*

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Specific heat measurements of $(Gd_{1-x}Y_x)_3T$ compounds (T= Co and Ni) revealed a strong concentration dependence of the coefficient γ of the T-linear specific heat. In particular, the electronic specific heat coefficient γ of Y_3Co was found to be significantly lower (15 mJ/molK^2) than that of isostructural Gd_3Co (110 mJ/molK^2) and $(Gd_{0.2}Y_{0.8})_3Co$ (380 mJ/molK^2). Such a behaviour can be attributed to the presence of a huge contribution of spin fluctuations in the d-electron subsystem induced by the f-d exchange interaction.

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1. Introduction

The enormous enhancement of the apparently linear temperature contribution γ to the specific heat in the vicinity of the onset of long range magnetic order of the system $(Gd_{1-x}Y_x)_3Co$ [1] stimulated further investigations also in the analogous pseudobinary system $(Gd_{1-x}Y_x)_3Ni$. Both end compounds Gd_3Co and Gd_3Ni exhibit complex magnetic structures below the Néel point [1–3] while no magnetic order occurs for Y_3T (T= Co, Ni) in particular down to 10 mK for the latter [4]. The dilution of Gd by Y leads to a breakdown of long range order below $x = 0.8$ in both systems which

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crystallize in the orthorhombic Fe_3C-type structure. The X-ray photoemission studies of R_3T compounds indicate that the almost empty rare earth $5d$ states ($4d$ in case of Y) hybridize with the transition metal $3d$ states and that the Fermi level is located just above the top of $3d$-band which is significantly narrower (1–1.7 eV) in comparison with pure $3d$-metals [2]. This observed narrowing of the $3d$-band in R_3T was attributed to the reduced overlap of the $3d$-orbitals owing to the large T–T distance (0.4 nm) in the Fe_3C-type lattice. Therefore, one may expect strong correlations between f- and d-electrons and a localization of spin fluctuations in R_3T.

2. Results and discussion

Shown in Fig. 1 is a comparison of the low temperature specific heat of $(Gd_{1-x}Y_x)_3T$ with T= Co, Ni and $x = 0, 0.8, 1$ which demonstrates that the enhancement of γ in the vicinity of the critical concentration for long range magnetic order is even larger in the Ni-system ($\gamma \simeq 425\,\mathrm{mJ/molK^2}$) than in the Co-system ($\gamma \simeq 380\,\mathrm{mJ/molK^2}$). The small anomaly at about 3.5 K in Gd_3T is attributed to the antiferromagnetic order of a small amount of Gd_2O_3. The critical concentration for the onset of long range magnetic order is situated slightly below $x = 0.8$, since both compounds $(Gd_{0.2}Y_{0.8})_3T$ exhibit cluster glass behaviour. The enhancement of γ for $x = 0.8$ is as large as a factor of 30 with respect to Y_3T ($\gamma^{Y_3Co} = 15\,\mathrm{mJ/molK^2}$, $\gamma^{Y_3Ni} = 14\,\mathrm{mJ/molK^2}$) and is a factor of about 4 with respect to the magnetically ordered compounds Gd_3T ($\gamma^{Gd_3Co} = 110\,\mathrm{mJ/molK^2}$, $\gamma^{Gd_3Ni} = 100\,\mathrm{mJ/molK^2}$).

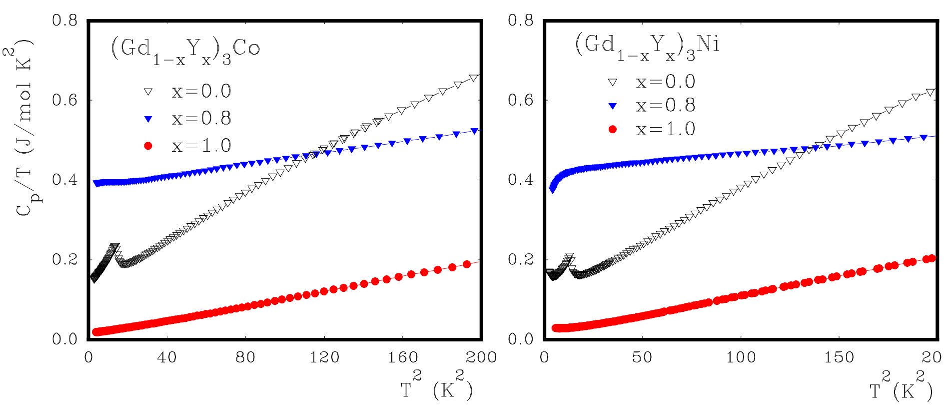

Fig. 1. The specific heat of $(Gd_{1-x}Y_x)_3Co$ and $(Gd_{1-x}Y_x)_3Ni$ with $x = 0.0$, 0.8 and $x = 1.0$.

An increase of the seemingly linear temperature contribution to the specific heat together with a maximal value of the residual resistivity in the vicinity of the critical concentration is a fairly common feature, however, γ values as high as 425 mJ/molK^2 are hardly attained [5]. To analyse this enhancement of γ we subtracted the lattice contribution of the respective Y_3T compound from the total heat capacity yielding $\Delta C_p(T)$. The results displayed in Fig. 2 indicate that $\Delta C_p(T)$ for $x = 0.8$ may be characterised as a broad Schottky-type anomaly. The maximum of this anomaly, which is not indicative for a second order phase transition, is shifted to lower temperatures as the Gd content is reduced yielding a sharp low temperature upturn

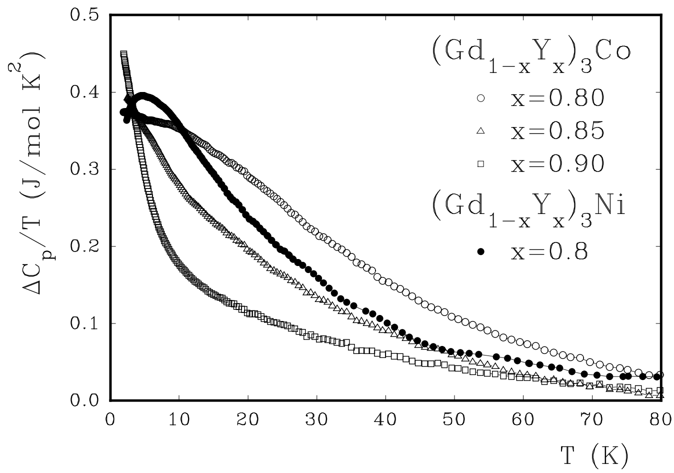

Fig. 2. The magnetic specific heat contributions of $(Gd_{1-x}Y_x)_3Co$ and $(Gd_{0.2}Y_{0.8})_3Ni$.

of ΔC_p for $(Gd_{0.1}Y_{0.9})_3Co$. External fields have a significant influence upon these anomalies, in particular the low temperature upturn of $\Delta C_p(T)$ for $x = 0.1$, 0.15 can be completely suppressed with external fields of 9 T (see Fig. 3). Thus, these anomalies which are also associated with the appearance of high residual resistivities of about 150 $\mu\Omega$cm can be attributed to the presence of a huge contribution of spin fluctuations in the *d*-electron subsystem induced by the *f*–*d* exchange interaction. The entropy associated with these anomalies reaches the expected value of $S = 3R(1-x)\ln 8$ at about 100 K for $x = 0.2$ and is slightly lower for the other concentrations ($x = 0.15$, 0.1) presumably due to the uncertainty of the low temperature extrapolation. This indicates that even in the paramagnetic regime strong magnetic correlations are present up to about 100K. Accordingly, the above mentioned correlations between *f*- and *d*-electrons due to the narrowing of the $3d$-band give rise to localised spin fluctuations which persist up to 100K in the paramagnetic concentration range.

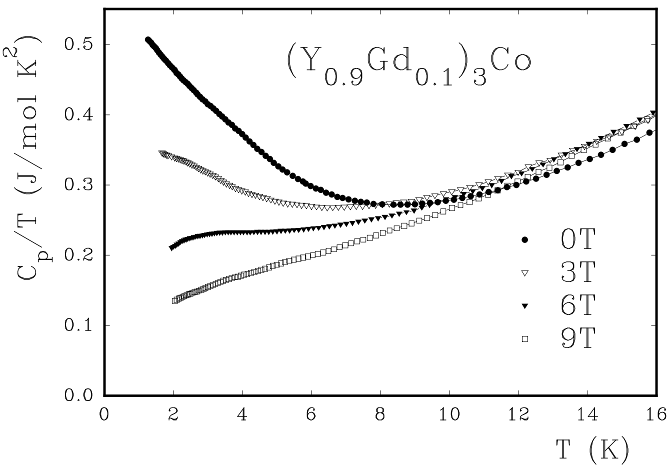

Fig. 3. The magnetic specific specific heat contributions of $(Gd_{1-x}Y_x)_3Co$ and $(Gd_{0.2}Y_{0.8})_3Ni$.

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