Thermoelectricity of EuCu$_2$(Ge$_{1-x}$Si$_x$)$_2$ intermetallics

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Abstract

The evolution of the thermopower $S(T)$ of EuCu$_2$(Ge$_{1-x}$Si$_x$)$_2$ intermetallics, which is induced by the Si–Ge substitution, is explained by the Kondo scattering of conduction electrons on the Eu ions which fluctuate between the magnetic 2+ and non-magnetic 3+ Hund’s rule configurations. The Si–Ge substitution is equivalent to chemical pressure which modifies the coupling and the relative occupation of the f and conduction states.

For $x < x_c$ the long-range magnetic order sets in, as indicated by an anomaly in $C_p(T)$ and the discontinuity of the slope of $\rho(T)$ at $T_N$. The AFM transition does not show up in $S(T)$ for $x > 0.6$ or $x < 0.3$ but for $0.60 \leq x \leq 0.3$ a cusp appears at $T_N$, making the overall shape of $S(T)$ quite different from what one finds in the non-magnetic samples. However, the shape of $S(T)$ above $T_N$ still looks much the same as in the non-magnetic samples well above $T_{\text{max}}^S$. That is, the transport properties of the paramagnetic phase exhibit the same pattern for all $x$ (see Fig. 6 of Ref. [2]). The XPS data indicate for $0.3 < x < x_c$ the presence of Eu$^{2+}$ and Eu$^{3+}$ ions [1,2] but the Eu$^{3+}$ component is less pronounced than for $x \geq x_c$. In Ge-rich samples, $x \leq 0.25$, the anomalies in $C_p$ and $\rho(T)$ are well defined but $S(T)$ is very small and does not indicate an AFM transition. (See Figs. 4 and 7 in Ref. [2].) Here, only Eu$^{3+}$ ions are detected in the XPS experiments.

The experimental results are explained by assuming that Si–Ge substitution is equivalent to chemical pressure, which changes the coupling and the relative occupation of the f and conduction states. To describe the Eu ions, which are allowed to fluctuate between the non-degenerate Hund’s rule ground state of the 4f$^0$ configuration and the 8-fold degenerate 4f$^7$ configuration by exchanging...
Fig. 1. The NCA result for the thermopower plotted versus temperature for various couplings $g = I/|E_I|$. The values of $E_I$ and $I$ are indicated in the figure.

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References