Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

Wissenschaftliche Berichte
FZKA 7430

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August 2008

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von der Fakultät für Physik der Universität Karlsruhe (TH) genehmigte Dissertation

Forschungszentrum Karlsruhe GmbH, Karlsruhe

2008

Forschungszentrum Karlsruhe GmbH
Postfach 3640, 76021 Karlsruhe

Mitglied der Hermann von Helmholtz-Gemeinschaft
Deutscher Forschungszentren (HGF)

ISSN 0947-8620

urn:nbn:de:0005-074307

Thermal Expansion and Magnetostriction of $CeCu_{6-x}Au_x$ at low temperatures

Abstract

A well-studied magnetic quantum critical point (QCP) exists at the onset of antiferromagnetic order in the heavy-fermion system $CeCu_{6-x}Au_x$ with a critical gold concentration of $x_c \approx 0.1$. Due to the instability at the QCP the entropy S shows at finite temperatures a maximum as a function of x, volume V, or pressure p. The maximum leads to a sign change of the thermal expansion coefficient, $\alpha = -(1/V)(\partial S/\partial p)$, and of the Grüneisen parameter Γ, the ratio of α and specific heat. This feature and the divergence of Γ at $T \to 0$ are important thermodynamic probes to detect and classify QCPs. This work describes the set-up of a high-resolution dilatometer in a ^{3}He/^{4}He dilution refrigerator and reports low-temperature thermal expansion and magnetostriction measurements on the critical concentration $x = 0.1$ and $x = 0.15$ with a Néel temperature of $T_N \approx 89\,\mathrm{mK}$. The thermal expansion was measured in a temperature range of $30\,\mathrm{mK} < T < 300\,\mathrm{K}$ in magnetic fields parallel to the c- and the a-axis of up to 3 T. The thermal expansion shows clearly the strong NFL behavior and a diverging Γ. A comparison with theoretical predictions for a spin density wave model though reveals a small mismatch and a slightly shifted maximum in $S(x)$. The possibility of an additional energy scale E^* is studied in the pressure and strain dependencies of α and Γ respectively. It is possible to map out a phase diagram for $x = 0.15$ from magnetostriction measurements. Comparing the change of different control parameters, such as pressure p and magnetic field B, the measurements reveal good scaling behavior for small changes of p and B. For larger changes a clear discrepancy in the critical behavior of p and B is measured.