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TITLE NORMAL STATE MAGNETIC BEHAVIOR OF $(U_{1-x}RE_x)Be_{13}$ PSEUDOBINARIES

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NORMAL STATE MAGNETIC BEHAVIOR OF $(U_{1-x}RE_x)BE_{13}$ PSEUDOBINARIES

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INTRODUCTION

To understand the underlying physics of the heavy electron superconductor UBe_{13},[1] its superconducting transition temperature T_c and its critical field behavior have been studied extensively as a function of impurity doping.[2-5] Thorium and yttrium substitution on uranium lattice sites generate a non-monotonic T_c suppression as a function of impurity concentration. Moreover, for Th-substitutions x, $0.02 < x < 0.04$, a second large anomaly appears[4] in the specific heat below T_c, perhaps indicating the transition to a second superconducting phase.[6] Doping of UBe_{13} with magnetic Gd impurities results in an unusually small T_c suppression (ΔT_c/Gd = -0.40 K/%). On the other hand, adding a few percent of nonmagnetic impurities (La, Sc, Lu) suppresses T_c rapidly, being an unusually strong effect of nonmagnetic impurities on superconductivity. Altogether, any impurity doping seems to modify the low temperature properties of UBe_{13} in a way rather unusual compared to normal superconductors. So far, however, little attention has been paid to the modification of the normal state properties of impurity doped UBe_{13}. We have investigated the normal state magnetic behavior of impurity doped $(U_{1-x}RE_x)Be_{13}$ pseudobinaries (RE = Th, Y, La, Lu, Sc) in the temperature range between 2 K and 380 K for impurity concentrations $x \lesssim 0.05$ to see if there are correlations with $T_c(x)$.

RESULTS

The magnetic susceptibilities χ of all samples investigated show Curie-Weiss behavior above 100 K. This allows us to extract reasonably accurate values for the paramagnetic Curie-temperature θ and the effective U-moment p_{eff} by fitting $1/\chi$ vs. T to a Curie-Weiss law in this temperature range. As a third parameter characterizing the magnetic behavior we choose the susceptibility per mole U at a temperature of 2 K, χ(2 K). Here we present results only on Y and La, having a comparable ionic volume to uranium, and on Lu and Sc, having a smaller ionic volume compared to uranium.[2] Figures 1(a) and (b) show as a function of Y and La concentration x, respectively from top to bottom, T_c taken from Ref. (5), the magnetic susceptibility per mole U at 2 K χ(2 K), the paramagnetic Curie-temperature θ and the effective paramagnetic U-moment p_{eff}. Additionally, in Figs. 2(a) and (b) the same parameters T_c, χ(2 K), θ and p_{eff} are shown as a function of Lu- and Sc-impurity concentration, respectively.

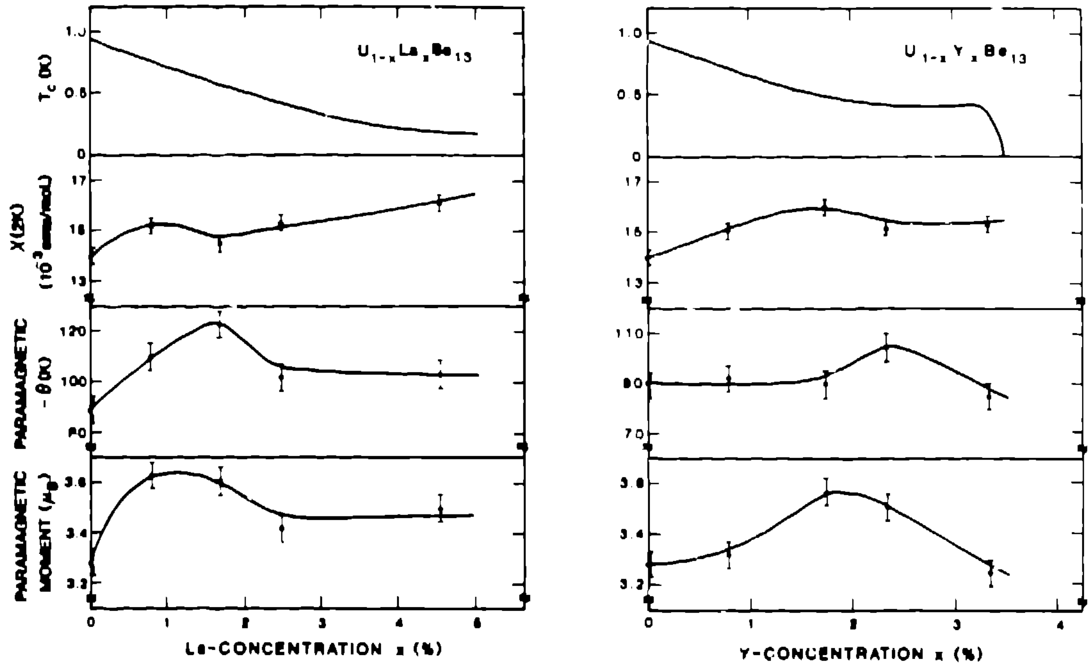

Fig. 1a   Fig. 1b

Fig. 1. Influence of impurity doping on the magnetic properties of UBe_{13}. Shown as a function of La-concentration (Fig. 1a) and Y-concentration (Fig. 1b) are the superconducting transition temperature T_C, the magnetic susceptibility per mole U at 2 K, χ(2K), the paramagetic Curie temperature θ and the paramagnetic effective U-moment. The solid lines are guides to the eye.

DISCUSSION AND CONCLUSIONS

For all different impurities shown in Figs. 1 and 2, we note an initial increase of the low temperature susceptibility χ(2 K) as a function of impurity concentration, which is also observed for Th impurities.[7] This may be explained as due to Kondo screening of a nonmagnetic impurity, resulting in the formation of an induced magnetic moment.[8] Simply speaking, at the location of the impurity there is a compensating electron cloud, but nothing to compensate.

For all types of impurities investigated, the paramagnetic Curie-temperature exhibits a maximum as a function of impurity concentration but does not change dramatically as can bee seen from Figs. 1 and 2. For Th impurities not shown here, where the whole concentration range from UBe_{13} to dilute U in $ThBe_{13}$ has been studied, θ changes by less than 30%, indicating that θ is dominated primarily by single-ion spin fluctuations.[7] Certainly this appears to be the case in pure UBe_{13} since the value of θ is to within ~10% the same value as the single Kondo impurity temperature deduced by Batlogg et al.[9] from a Bethe Ansatz analysis of their magnetoresistance data.

Surprisingly, we not only observe changes in χ(2 K) and θ as a function of impurity concentration, which both are consistent with a simple Kondo picture, but also changes in the paramagnetic effective moment of U in UBe_{13} due to impurities. As can be seen from Figs. 1 and 2 for all types of impurities investigated, we observe an increase of the U-moment with increasing impurity concentration, going over a maximum, and settling at values higher than or comparable to that for pure UBe_{13}. The maximum seems most pronounced for Y- and La-impurities, which are comparable in

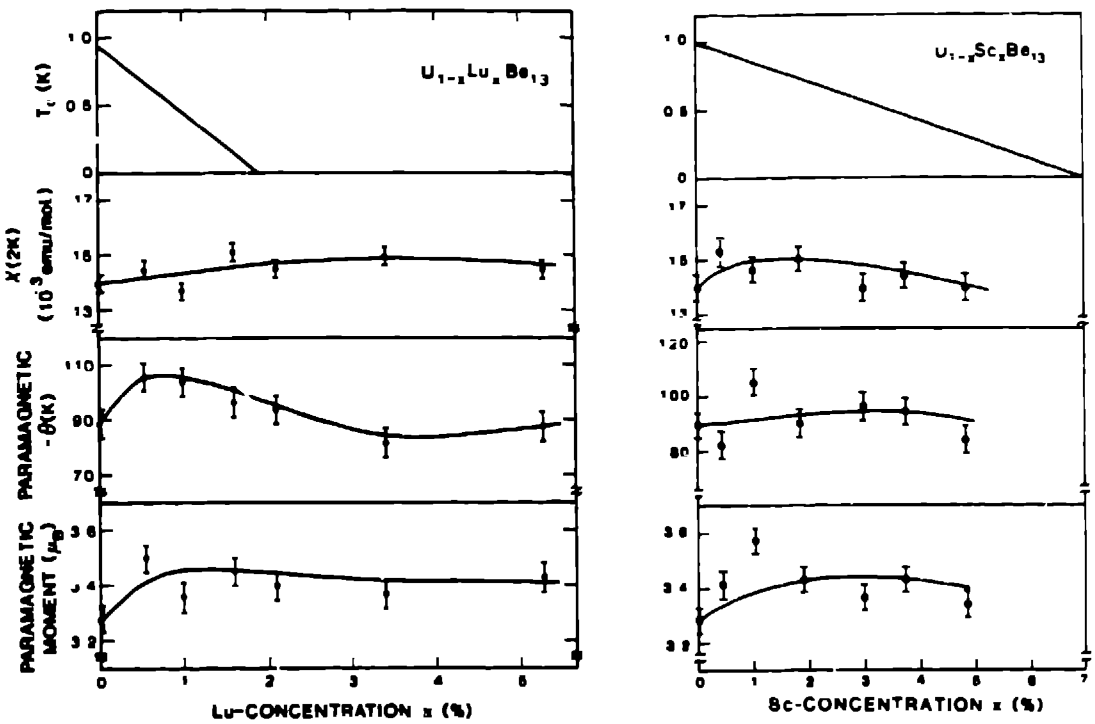

Fig. 2a   Fig. 2b

Fig. 2. Influence of impurity doping on the magnetic behavior of UBe_{13}. Shown as a function of Lu-concentration (Fig. 2a) and Sc-concentration (Fib. 2b) are the superconducting transition temperature T_c, the magnetic susceptibility per mole U at 2 K, χ (2 K), the paramagnetic Curie temperature θ and the paramagnetic effective U-moment. The solid lines are guides to the eye.

volume to U, and less pronounced for the smaller volume Sc and Lu. Inspection of Figs. 1 and 2 shows that the variation in p_{eff} with concentration qualitatively tracks $\theta(x)$. The change in p_{eff} with concentration might be merely reflecting variations in p_{eff} with x and both may have a common origin. However, alternative interpretations of p_{eff} varying with impurity concentration, like changes in the hybridization between U 5f-electrons and electrons of neighboring Be-ions, cannot be ruled out on the basis of these observations alone. Clearly, there are rather significant changes in the magnetic behavior of doped UBe_{13} samples that accompany the depression of T_c. Further investigations, e.g. magnetoresistance, Hall effect, and neutron scattering measurements, are needed to establish unambiguously their origin so that a relevant theory for superconductivity in these materials can be made.

REFERENCES

1. H. R. Ott, H. Rudigier, Z. Fisk and J. L. Smith Phys. Rev. Lett. 50 1595 (1983).
2. J. L. Smith, Z. Fisk, J. O. Willis, A. L. Giorgi, R. B. Roof, H. R Ott, H. Rudigier and E. Felder, Physica 135B, 3 (1985).
3. J. O. Willis, J. L. Smith, Z. Fisk and H. R Ott, J. Appl. Phys. 57, 3079 (1985)
4. H. R. Ott, H. Rudigier, E. Felder, Z. Fisk and J. L. Smith, Phys. Rev. B 33, 126 (1986).
5. J. L. Smith, Z. Fisk, J. O. Willis, H. R. Ott, S E. Lambert, Y. Dalichaouch and M. B. Maple, J Magn. Magn. Mat. (in press).

6. U. Rauchschwalbe, F. Steglich, G. R. Stewart, A. L. Giorgi, P. Fulde and U. Maki (unpublished).
7. E. Zirngiebl, H. A. Borges, J. D. Thompson, J. L. Smith and Z. Fisk (unpublished).
8. J. M. Lawrence, J. D. Thompson and Y Y. Chen, Phys. Rev. Lett. 54, 2537 (1985); S. Schmitt-Rink, K. Miyake and C Varma, Phys. Rev. Lett. 57, 2575 (1986).
9. B. Batlogg, D. J. Bishop, E. Bucher, B. Golding, A P. Ramirez, Z. Fisk, J. L. Smith and H. R. Ott, J. Magn Magn Mat. (in press).