MAGNETIC SUSCEPTIBILITY AND SPECIFIC HEAT STUDY ON THE NONMAGNETIC TO MAGNETIC TRANSITION IN URh3Bx ($0 \leq x \leq 1$) SYSTEM

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MAGNETIC SUSCEPTIBILITY AND SPECIFIC HEAT STUDY ON THE NONMAGNETIC TO MAGNETIC TRANSITION IN URh_3B_x $(0 \leq x \leq 1)$ SYSTEM

T. Yuen, I. Perez, J. E. Crow, G. H. Myer and P. Schlottmann

Center for Materials Research, Temple University, Philadelphia, Pennsylvania 19122, U.S.A.

Abstract. – Lattice parameter, suceptibility, specific heat and resistivity measurements are presented on URh_3B_x $(0 \leq x \leq 1)$. This alloy series exhibits a transition from an almost temperature independent paramagnet to a magnetic system. Results are interpreted in terms of U-5f Rh-4d dehybridization induced by boron addition.

One cf the basic parameters dictating the properties of f-electron systems is the degree of hybridization of the f-electrons with the conduction band electrons [1]. The alloy system URh_3B_x with $0 \leq x \leq 1$ exhibits a transition from an itinerant paramagnet ($x = 0$) to an antiferromagnet ($x = 1$) in which the 5f hybridization effects can be studied in a continuous way as a function of x. URh_3 is a temperature independent paramagnet [2] where the 5f electrons are itinerant, while URh_3B exhibits a Curie-Weiss susceptibility and orders antiferromagnetically at 9.8 K [3] suggesting a more local nature of the 5f electrons.

URh_3 and URh_3B parents were prepared by arc melting in an argon atmosphre stoichiometric amounts of appropriate elements of higher than 99.9 % purity. X-ray patterns of both compounds showed single phase $AuCu_3$ structure with lattice parameters of 3.98 Å and 4.14 Å respectively in agreement with previous studies [2, 3]. Parents were then cut into few pieces, mixed in the appropriate ratios and remelted to form the final URh_3B_x alloys with $0 \leq x \leq 1$. No second phases were detected by X-ray diffraction.

Lattice parameter measurements are shown in figure 1a. The lattice parameter increases almost linearly up to $x \sim 0.8$ after which the lattice parameter stabilizes. As stated above, careful X-ray studies for $x > 0.8$ indicate that these samples are single phase. Thus, the nonlinearity of the x-dependence of the lattice constant reflects that boron addition not only expands the lattice but also changes the electronic structure of the matrix presimably by bonding with the Rh atoms [4] and by adding electrons to the conduction band. Similar behavior was found in all the LRh_3B_x where L =rare earth element [5].

Susceptibility measurements were done using a dc SQUID magnetometer in a external field of 10 kOe. The data (Fig. 2) was fitted to a Curie-Weiss susceptibility plus a constant, $\chi = \chi_0 + C/(T - \theta)$. In figure 1b we show the fitted values for the high temperature paramagnetic moment and the Curie-Weiss temperature θ. The susceptibility data shows a cusp (Fig. 2) for $x = 1.0$ and $x = 0.9$ at T_N=9.8 K and 6.8 K respectively. This magnetic anomaly is believed

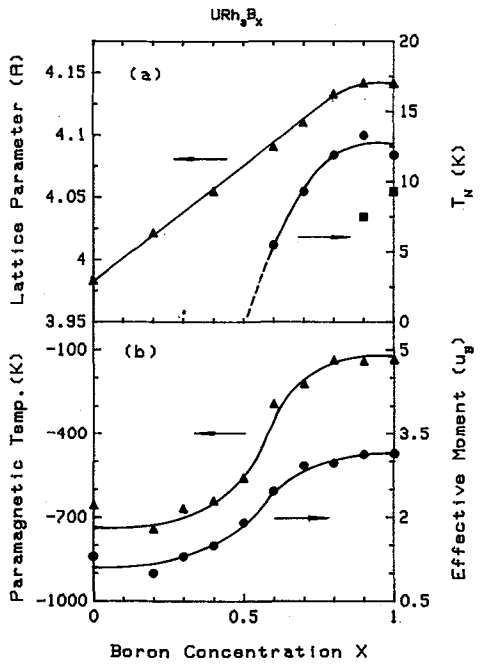

Fig. 1. – a) Temperature of the magnetic anomaly T_N as determined from zero-field resistivity (circles) and susceptibility at 10 kOe (squares) and lattice parameter (triangles) as a function of boron concentration; b) high temperature paramagnetic moment μ_p (circles) and Curie-Weiss paramagnetic temperature θ (triangles) as a function of boron concentration.

to be due to antiferromagnetic or spin glass-like ordering of the U ions. This speculation is supported by the fact that the high temperature paramagnetic moment, $\mu_p = 3.2\ \mu_B$, is close to that of the free uranium $U^{2+,3+}$ ion ($\mu_p = 3.6\ \mu_B$) and T_N decreases with field as expected for an antiferromagnet. The large negative values of θ point to strong hybridization of the f-electrons, which decreases with increasing x.

From figure 1 we may divide the alloy series into three different regions; $x \leq 0.5$, $0.5 < x < 0.8$ and $0.8 \leq x$. In the first region, $x \leq 0.5$, boron addition

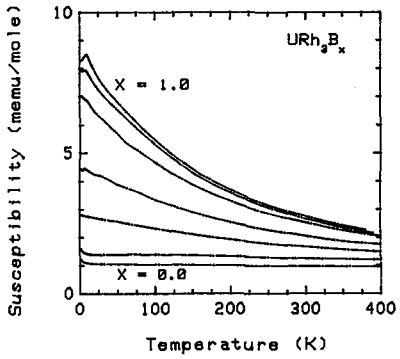

Fig. 2. – Susceptibility as a function of temperature for various boron concentrations $x = 0.0$; 0.5; 0.6; 0.7; 0.8; 0.9 a,d 1.0.

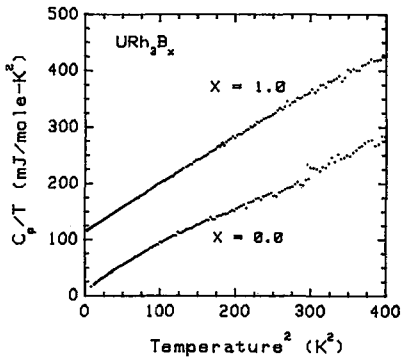

Fig. 3. – Specific heat over temperature *versus* T^2 for URh_3 and URh_3B. γ values are 14 and 114 mJ/mole-K^2 for $x = 0.0$ and 1.0 respectively.

expands the lattice but the 5f electrons remain essentially itinerant. In the second region, $0.5 < x < 0.8$, boron addition expands the lattice even further but the 5f electrons start to dehybridize as indicated by the increase of μ_p and θ. At $x = 0.8$, $\mu_p = 3.2\ \mu_B$ is almost that of the free uranium atom $U^{2+,3+}$. In the third region these quantities stabilize and clear evidence for a magnetic transition is seen in $\chi(T)$.

A change in slope in the resistivity is seen at temperatures close to T_N, as defined by the cusp in $\chi(T)$. This allows for an independent estimate of the magnetic ordering temperature shown in figure 1a. From there we see an increase in the transition temperature as a function of boron content with further stabilization at around $x = 0.8$. These results track the susceptibility ones and are further evidence of the dehybridization.

Finally, in figure 3 the specific heat C_p is plotted as C_p/T *versus* T^2 for URh_3B. The electronic contribution to C_p, i.e. γ, is enhanced by about one order of magnitude (from 14 mJ/mole-K^2 to 114 mJ/mole-K^2). This increase in γ also points towards a dehybridization of the 5f electrons induced by boron addition. Surprisingly, there is no anomaly in the specific heat of URh_3B as would be expected for an antiferromagnetic system. This result shadows the interpretation of the magnetic anomaly as originated from an antiferromagnetic orderidng. Currently these studies are extended to include ac susceptibility, time-dependent magnetization and mössbauer measurements to check for spin glass-like behavior.

Acknowledgements

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