C3.3 LOW TEMPERATURE SUSCEPTIBILITY AND SPECIFIC HEAT IN $Cu_6La_{1-x}Er_x$ ALLOYS*. R. Yee and George O. Zimmerman

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We have investigated the $Cu_6La_{1-x}Er_x$ system, with x between 0 and 0.02, by measuring the real and imaginary parts of the complex magnetic susceptibility, and the specific heat.

The samples were prepared from the pure elemental metals obtained from MRC[1], by arc-melting in an inert atmosphere. The resulting buttons were then ground into cylinders having dimensions of about 0.620" dia. x 0.130" thick and weighing on the average of 6.5 gms.

The in phase, χ', and out of phase, χ'', components of the magnetic susceptibility were measured using a.c. bridge techniques described earlier[2]. Cooling of the samples was obtained by using $FeNH_4(SO_4)_2 \cdot 12H_2O$ as the cooling salt in the adiabatic demagnetization and its susceptibility determined the temperature of the sample when the two were closely coupled. For lower temperatures where the salt susceptibility deviated from the Curie law, the salt susceptibility was calibrated by using a single crystal of cerous magnesium nitrate as a thermometer.

Specific heat measurements were made using the technique described by Haseda and Miedema[3], but using the susceptibility of the sample to determine its temperature.

Figures 1, 2, and 3 show the results obtained for χ', χ'' and C. In these plots, x is the atomic fraction of erbium present in the sample. Figure 1 shows the in phase component and Figure 2 the out of phase component of the susceptibility as a function of inverse temperature. From Figure 1 one can see that all samples containing Er show a paramagnetic susceptibility at the higher temperatures. In the paramagnetic region the susceptibility generally increases with the erbium concentration. At lower temperatures, the samples exhibit a susceptibility maximum indicative of an antiferromagnetic transition. These maxima occur at 0.080°K, 0.070°K and 0.057°K for the samples with x = 0.02, 0.01, and 0.005 respectively. The maxima shift toward lower temperatures for samples having lower erbium concentrations.

At about .04°K, the χ'' vs. T^{-1} graphs of Figure 2, and also the graphs in Figure 1 indicate that the samples undergo a resistive transition. This transition is not well defined in the erbium doped samples, but is quite obvious in the pure Cu_6La. One should note the scale change in Figure 2 for χ'' of the pure Cu_6La sample. It appears that the paramagnetism of the erbium doped samples tends to suppress this resistive transition since there are clearer indications of its occurence in the samples having the more dilute erbium concentration.

The resistive transition in the pure Cu_6La sample is also manifested in the χ' vs. T^{-1} graph of Figure 1. Initially, the sample is weakly diamagnetic over most of its measured temperature range, but at about .04°K it becomes strongly diamagnetic suggesting that a superconducting transition has occured. Lanthanum is known to be a superconductor having a transition temperature of about 6°K. Furthermore, it is known that the addition of impurities can change the transition temperature. It is, therefore, probable that one is observing the suppressed superconducting transition of lanthanum in this sample. The χ', χ'' data obtained for the pure Cu_6La sample are similar to the results obtained by Strongin et al[4] in their a.c. susceptibility measurements on transition metal superconductors containing rare earth ferromagnetic metal solutes.

Figure 3 shows the specific heat of two samples. The singularities occur at temperatures somewhat above the antiferromagnetic transition shown in the susceptibility measurements.

The specific heat near a singularity increases with the Er concentration, making it hard to carry out specific heat measurements at temperatures below the maximum except in the very dilute samples. The singularities have the typical shape of specific heat at a cooperative transition, in this case, antiferromagnetic.

REFERENCES

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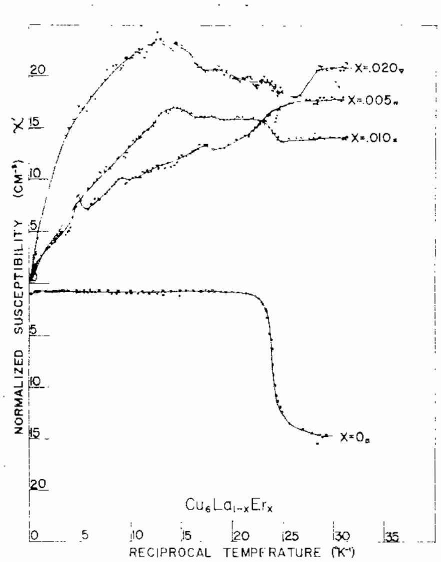

Figure 1

χ' vs T^{-1}

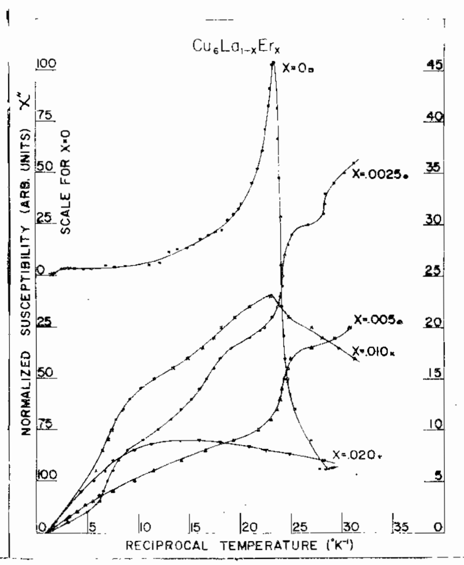

Figure 2

χ'' vs T^{-1}

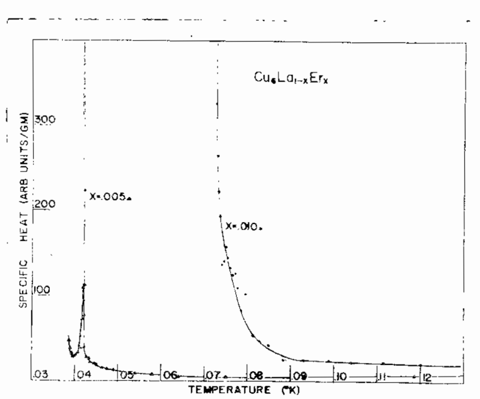

Figure 3

Specific Heat vs T