ELECTRONIC TRANSFER IN U(Cu, Ni)$_5$[1])

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Magnetic and electrical properties of the quasibinary system $U(Cu_{1-x}Ni_x)_5$ are discussed in terms of a simple band model. Antiferromagnetism of UCu_5 with a considerable amount of occupied $5f$ states disappears as a result of the shift of the Fermi energy to the vicinity of the minimum between the $5f$ and the $3d$ states with increasing Ni content.

ПЕРЕНОС ЭЛЕКТРОНОВ В СИСТЕМЕ U(Cu, Ni)$_5$

В работе обсуждаются магнитные и электрические свойства квазибинарной системы $U(Cu_{1-x}, Ni_x)_5$ на основе простой зонной модели. Антиферромагнетизм UCu_5, обусловленный значительным заселением $5f$ состояний, с увеличением содержания никеля понижается, так как энергия Ферми сдвигается к минимуму плотности состояний между $5f$ и $3d$ состояниями.

I. INTRODUCTION

The behaviour of uranium Laves phases in the sequence UF_2, UCo_2, UNi_2 can be explained by a model based on the idea of electronic transfer from the $5f$ and the $6d$ states of uranium to the empty ones in the $3d$ band because of a difference of electronegativities of the constituents. The $5f$ band is situated at a higher energy in this model [1]. Unfortunately the uranium Laves phase with Cu is not formed and we cannot follow this trend further. On the other hand the Laves phase derived structure of the $AuBe_5$ type can be observed for uranium with Ni and Cu. In this contribution we discuss whether the idea of electronic transfer can be used in the case of these intermetallics as well.

The properties of these compounds were measured by several authors [2, 3, 4]. UCu_5 is reported as an antiferromagnet with $T_N = 15$ K. The investigation of the quasibinary system $U(Cu_{1-x}Ni_x)_5$ was performed by van Daal et al. [5]. On the basis of the lattice constant, the specific heat, susceptibility, electrical resistivity and the Seebeck coefficient measurements the possible mixed valence of uranium was proposed in the case of UCu_5. Recent resonant photoemission measurements [6] indicated the itinerant behaviour of the $5f$ electrons, partly due to the hybridization with the $3d$ electrons. Under these circumstances the electronic transfer can be a plausible explanation of behaviour changes when proceeding from UCu_5 to UNi_5, the magnetic properties of which are very weak. We have measured the temperature dependence of magnetic susceptibility and electrical resistivity of this system so as to observe the dependence of the increasing rate of the $5f$ band filling on these quantities.

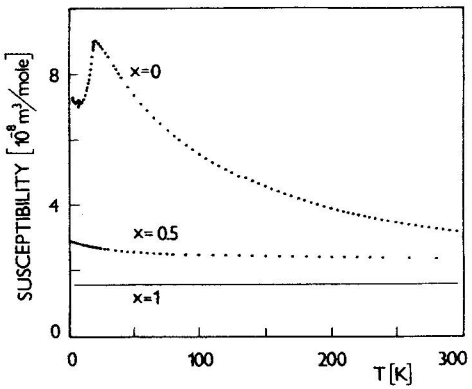

Fig. 1. Temperature dependence of magnetic susceptibilities of $U(Cu_{1-x}Ni_x)_5$ measured in the field of 6 T.

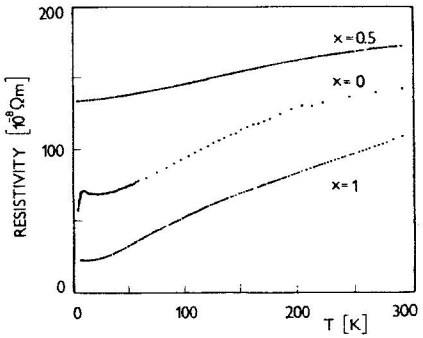

Fig. 2. Temperature dependence of electrical resistivity of $U(Cu_{1-x}Ni_x)_5$.

II. EXPERIMENTAL AND DISCUSSION

Polycrystalline samples of UCu_5, UNi_5 and $U(Cu_{0.5}Ni_{0.5})_5$ were prepared. Magnetic susceptibility measured by the Faraday balance method is plotted in Fig. 1. A modified Curie-Weiss behaviour $\chi \sim (T - \Theta_p)^{-1} + \chi_0$ is observed for UCu_5. The least square fit gives the values $\Theta_p = -78$ K, $\mu_{eff} = 2{,}25\ \mu_B$ and $\chi_0 = 1.0 \times 10^{-8}$ m^{3}mol^{-1}. UNi_5 and $U(Cu_{0.5}Ni_{0.5})_5$ have only weak magnetic properties. Results of resistivity measurements are seen in Fig. 2. The behaviour of UNi_5 with a low residual resistivity $\varrho_0 = 22 \times 10^{-8}$ Ωm and a linear high temperature dependence is typical for metals with a not very high density of states at E_f. For $U(Cu_{0.5}Ni_{0.5})_5$ the high $\varrho_0 = 134 \times 10^{-8}$ Ωm is the result of the structural disorder that can influence the high temperature departure from linearity, too. For UCu_5

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a downwards curvature at higher temperatures was observed as a result of a high density of states present at E_F. At low temperatures the resistivity is dominated by a maximum at 10 K, the origin of which is influenced probably by the antiferromagnetic transition, nevertheless there exist some other effects that can provide similar behaviour of the resistivity as a thermal dehybridization of the $5f$ states.

III. CONCLUSION

We can conclude that E_F is situated in the region of a relatively low density of states for UNi_5. A similar situation can be supposed for $U(Cu_{0.5}Ni_{0.5})_5$, while the $5f$ states start to be occupied in the case of UCu_5. This presentation is fully consistent with the idea of electronic transfer used in the case of the Laves phases of uranium.

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