INTERACTIONS IN KONDO-ALLOYS

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In 1969. Star[1] demonstrated that the concentration dependent effects may appear even in the ppm region for the alloys with a low Kondo temperature (T_K). Another type of interaction sets in at somewhat higher impurity concentrations. This long range interaction between the well defined impurity moments may lead to a spin glass state at low temperatures.

In this paper we wish to point out the distinction between two types of interaction and to show that the first one also causes well defined properties. Furthermore, in order to account for the properties of various alloy systems we propose the phase diagram for different interaction regions.

In an earlier paper[2] we have shown that by using the idea of many-body screening of the impurity spin[1] one can derive an approximate expression for the concentration dependence of T_K:

$$\ln(T_K/T_K^0) = -c/c_{crit} \qquad (1)$$

Here $c_{crit} = \alpha(NT_K/2ST_F)$ with N the number of electrons per atom in the conduction band, S the impurity spin value and α takes a care of the difference in the shapes of the conduction band and the Kondo resonance.

The Kondo temperatures of three alloy systems (AlCr, AlMn and CuFe) determined from:

$$\rho_T = \rho_0(1 - (T/T_K)^2) \qquad (2)$$

(with ρ_0 residual resistivity and ρ_T impurity resistivity at given temperature) were found[2] to vary logarithmically with concentration as predicted by eq.(1). The data for other Kondo alloys are less detailed which prevents a wider comparison.

At this point we emphasize that the physical properties of the system in this region would be very different from those found in spin glasses[3]. As this region appears to be between the single impurity case and that of the highly correlated electron gas the properties resembling both are expected. Therefore the impurity resistivity at low temperatures ($T \ll T_K$) will be proportional to $\pm T^2$, the specific heat linear in temperature and the magnetic susceptibility (also proportional to T^2) will be enhanced, but all with the coeficients nonlinear in concentration.

We note that the proposed picture of the impurity interactions is different from that based on the local configuration effects (l.c.e.). To our opinion these effects are dominant only at higher concentrations where the nearest neighbour groups of impurity atoms have a high probability.

Finally we note that interaction effects both due to the concentration dependent Kondo-screening and due to the RKKY coupling between the impurity spins could be observed in some cases in the same alloy. In that case two effects work against each other[2].

Fig.1 shows a phase diagram for an alloy where both types of interactions are important. At lower concentrations there is a

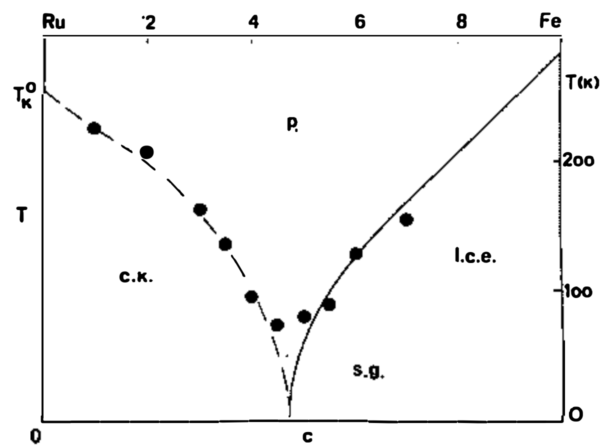

Figure 1. Phase diagram for interactions in RuFe system

smooth transition from the high temperature paramagnetic region (p) to the low temperature collective Kondo state. With increasing concentration T_K tends to zero and the long range RKKY coupling takes over giving rise to a spin glas (s.g.) state at lower temperatures. At these concentrations also the local configurational interactions (l.c.e.) become increasingly important.

The phase diagram on Fig.1. is also supported by the behaviour of T_K of Ru Fe solid solutions which were investigated by Sarkissian and Coles[4] in a very broad concentration interval. It can be seen that the behaviour of this system is remarkably well described by the proposed phase diagram. We believe that many other systems can also be successfully described by this diagram. This work is now in progress.

References:

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