TRANSPORT AND MAGNETIC PROPERTIES OF CERIUM BASED KONDO SYSTEMS

K. R. Priolkar*

Department of Physics, Goa University, Taleigao Plateau, Goa 403 206 India†

The study of cerium based Kondo systems has achieved a lot of significance due to a variety of exotic ground states these materials exhibit. In the concentrated Kondo systems (CKS) two interactions, the intrasite, Kondo interaction and the intersite, RKKY interaction compete with each other in the formation of the ground state. The dominance of one interaction over other depends upon the $4f$ and conduction electron hybridization.

We have investigated one such cerium CKS, viz; $CeSi_{2-x}Ga_x$ by different experimental techniques: magnetization as a function of temperature and field, specific heat, magnetic inelastic neutron scattering and resistivity.

Inelastic neutron scattering gives a direct evidence of magnetic excitations like spin waves, crystal field excitations in solids. This being our first attempt we have studied inelastic spectra of well characterized $CeSn_2In$ and our estimated quantities match well with those reported in literature.

$CeSi_{2-x}Ga_x$ exhibits different types of ground states in different regions from x = 0 to 2. We have concentrated on two regions, $0.7 \leq x \leq 1.3$ and $1.4 \leq x \leq 2.0$. In the first region, the system has tetragonal structure and orders ferromagnetically with ordering temperature decreasing with increasing Ga concentration. In the second region, the samples crystallize in a hexagonal structure with x = 1.4 being ferromagnetically ordered while others are antiferromagnetic. $CeGa_2$ of-course shows more than one magnetic transition between 8 - 11K.

The major findings of this investigations are as follows:

1. In the region $0.7 \leq x \leq 1.3$ the ferromagnetic ordering is mediated through antiferromagnetic coupling. The decrease in magnetic ordering temperature is due to increasing dominance of Kondo interactions over RKKY interactions with increasing x. This can be seen from increasing negative paramagnetic curie temperatures and decreasing magnetic entropy. The Kondo temperatures estimated from resistivity curves also support this.

2. Kondo temperatures estimated from residual quasielastic linewidth (Γ_{QE}) agree well with those calculated from other studies. It has been clearly shown, from the analysis of thermal evolution of Γ_{QE} that the dominance of Kondo interactions over RKKY interactions results from the increasing $4f$ conduction electron hybridization.

3. From the crystal field analysis, it has been shown that the ground state in these systems is a doublet. In case of $x = 0.7$, Ce j = 5/2 multiplet is split in a doublet and a 'quasiquatret' which is perhaps due to anomalous damping of the spin wave excitations. In the other systems the 5/2 multiplet is split in three doublets as expected in a tetragonal point symmetry.

4. An attempt has been made to calculate transport properties from neutron Γ_{QE} using a phenomenological model. From this analysis it has been shown that in the case of $x = 0.7$ the $4f$ level is localized in a narrow energy region below the Fermi level as the system cools from 300K to 0K which is expected for a RKKY dominated system. In the other compounds, $4f$ level moves towards the Fermi level as the system is cooled to 0K as expected for a system in which Kondo interactions dominate.

5. In the other region, $1.4 \leq x \leq 2.0$, the magnetic ordering temperature increases with increasing Ga concentration. This is inferred to be due to localization of $4f$ level because of larger Ga ion as compared to Si. The change in nature of magnetic order then can be linked to the value of the lattice sum fraction $\sum_i(2k_F R_i)$, where k_F is the Fermi wave vector and R_i is the sum over all magnetic moment sites in the crystal lattice.

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†email: prsarode@unigoa.ernet.in