ABSTRACT

The magnetic properties (like critical behaviour, scaling behaviour of magnetization, linear and non-linear magnetic responses, phase boundary) of disordered magnetic system are studied theoretically to have a qualitative understanding of experimental results on the magnetic alloys. A binary Ising alloy A_pB_{1-p}, where A and B are magnetic atoms, with competing exchange interaction, is modelled to represent the disordered magnetic system. The approximate free energy is evaluated using the cluster variational method and hence the above magnetic properties are derived.

The critical exponents γ^* and $\hat{\gamma}$ describing respectively the linear and non-linear scaling of susceptibility, exhibit non-monotonic temperature dependence for $T>T_c$. The exponent γ^* increases with the increase of disorder. The critical exponent β increases with disorder, whereas δ remains unaffected. A rapid shrinking of the asymptotic critical region and variation of limiting ($T>>T_c$) value of $\hat{\gamma} = \theta_p/T_c$ with the increase of disorder are important results. The linear and non-linear responses of the alloy exhibiting spin-glass behaviour are calculated for the temperatures $T \geq T_g$, the spin-glass transition temperature. The empirical formulae for these responses, which follow from the experimental results on concentrated spin-glass systems $Fe_{12}Ni_{63}G_{25}$ and $Fe_7Ni_{73}G_{20}$ for T close to T_g are obtained. The numerical results show that the thermal behaviour of zero-field susceptibility χ_o for the entire range of T can be represented by the formula $\chi_o^{-1}(T) - \chi_o^{-1}(T_g) = At'^{\gamma}(1-t')^{-1}$ where

$t' = (T - T_g)/T$. A scaling plot constructed from numerical data for reduced non-linear response R in presence of field h points out that $Rt^{-\beta}$ is a universal function of $h^2/t^{\gamma+\beta}$ where $t = (T - T_g)/T_g$. Considering thermally activated dynamics it is shown that both $\chi'(\omega)$ and $\chi''(\omega)$ in spin-glass phase exhibit one maximum with T. The scaling behaviours like $\chi'/\chi'_p = f(T/T'_p)$ and $\chi''/\chi''_p = g(T/T''_p)$ where χ'_p and χ''_p are maximum values occuring at T'_p and T''_p respectivly, are also observed. Magnetic properties of a model ternary alloy $(A_xB_{1-x})_{1-r}C_r$ representing metallic-glass system are also studied. Depending on X, r and J_{AB}, the exchange interaction between A and B, the alloy exhibits the ferromagnetic phase with complete or incomplete magnetic saturation, re-entrant behaviour or spin-glass like phase. The magnetic response of an unsaturated ferro-phase exhibits superparamagnetic-like behaviour at low T.

The electronic density of states, magnetic and transport properties in the normal state of a two-dimensional electronic system are studied assuming weak electronic correlation limit, theoretically, based on periodic Anderson model.

Key words : Disordered, Ising system, Critical behaviour, Re-entrant magnetic phenomenon, Spin-glass, 2-D periodic Anderson lattice, Electronic states, transport properties.