stant, it can be shown that a periodic regime is established in the system, and its period and amplitude depend on the ratio of V to the magnon interaction constants Ψ and Φ.

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EFFECT OF NONMAGNETIC IMPURITIES ON THE CURIE TEMPERATURE OF DILUTE FERROMAGNETIC ALLOYS

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It is shown that introduction of a small concentration of nonmagnetic impurities in dilute ferromagnetic alloys of the PdFe type can change the Curie temperature in a wide range. Measurement of T_C can yield information on the states of the magnetic impurities in the alloy.

The ferromagnetism of dilute alloys of the PdFe type is due to indirect exchange interaction of the localized moments of the impurities via strongly correlated holes in the narrow d-band; this interaction decreases with the distance r between impurities in accordance with the expression $V(r) \sim \exp(-r/R_0)$ [1].

We have shown in [2] that in the case when the average distance between impurities $r_{av} >> R_0$, the Curie temperature of the alloy is of the order of the interaction energy of impurities the spacing between which is equal to the average distance, and depends on the magnetic-impurity concentration as

$$T_C \sim \exp\left(-\frac{\gamma}{R_0 n^{1/3}}\right),$$

where γ is a coefficient of the order of unity. Such a dependence agrees well with experiment [2, 3].

We show in the present paper that by introducing a small concentration of nonmagnetic impurities in dilute ferromagnetic alloys of the PdFe type it is possible, depending on the properties of these impurities, to decrease as well as to increase T_C in a wide range; in particular, we present an explanation of the results of [3, 4]. In addition, it will be shown that measurement of T_C can yield information on the states of nonmagnetic impurities in the alloy.

In the Hubbard model, the Hamiltonian of the electrons in an alloy $A_{1-c}B_c$ of an almost-magnetic alloy A with nonmagnetic impurities B having a concentration $c << 1$ is given by

$$\mathcal{H} = \mathcal{H}_0 + \mathcal{H}_1 + \mathcal{H}_2, \tag{1}$$

$$\mathcal{H}_0 = \sum_{k,\sigma} \varepsilon_{k,\sigma} a^+_{k,\sigma} a_{k,\sigma} + I \sum_{\ell} n_{e\uparrow} n_{e\downarrow}, \tag{2}$$

$$\mathcal{H}_1 = U \sum_{\ell_B} \sum_{k,q,\sigma} a^+_{k+q,\sigma} a_{k,\sigma} e^{iqr_e} \qquad \mathcal{H}_2 = \Delta \sum_{\ell_B} n_{e\uparrow} n_{e\downarrow}, \tag{3}$$

where $\Delta = I_B - I$, and I_B is the correlation energy in a site occupied by an impurity.

The Hamiltonian $\mathcal{H}_2$ describes the potential scattering by the impurities, the summation over ℓ_B is carried out over the site occupied by impurities, and the remaining notation is standard.

We consider first the situation when the perturbation $\mathcal{H}_2$ can be neglected. In this case the energy of interaction of the magnetic impurities placed in the nonmagnetic alloy $A_{1-c}B_c$ is proportional to the alloys susceptibility averaged over the positions of the nomagnetic impurities, and the interaction radius is determined by the static homogeneous susceptibility,

given in the case c << 1 by

$$\chi^{-1} \sim 1 - I\rho_0(\epsilon_F)[1 + (F_1 - F_2)c]. \tag{4}$$

Here $\rho_0(\varepsilon)$ is the density of states of the pure metal A. The quantity F_1 is connected with the change of the Pauli susceptibility. It is due, first, to the difference between the valences of the atoms A and B, and second to the damping of the d-electrons as a result of potential scattering by the impurities. It can be either positive or negative. The quantity F_2 is connected with the renormalization of the electron correlation energy and is always positive. F_1 and F_2 depend strongly on the form of the electron spectrum. Using the connection between the interaction radius R and the static susceptibility [1], we obtain

$$R = R_0(1 + Dc)^{-1/2}, \tag{5}$$

where

$$|D| = |F_2 - F_1|[1 - I\rho_0(\epsilon_F)]^{-1} >> 1. \tag{6}$$

Thus, the Curie temperature of a ternary alloy is

$$T_C = T_C^0 \exp\left[-\frac{\gamma}{n^{1/3}R_0}(\sqrt{1 + Dc} - 1)\right]. \tag{7}$$

Since $n^{1/3}R_0 << 1$ and $|D| >> 1$, it follows that T_C can differ strongly from T_C^0 even at very low concentrations of the magnetic impurities.

If Dc << 1, then the nonmagnetic impurities experience very little change in saturation susceptibility, magnetization, and R_0. The Curie temperature, which in this case is equal to

$$T_C = T_C^0 \exp\left(-\frac{\gamma}{n^{1/3}R_0}\frac{Dc}{2}\right) \tag{8}$$

can at the same time experience large changes, increasing or decreasing in accordance with the sign of D. It follows from (8) that for small c we have $\ln(T_C/T_C^0) \sim n^{-1/3}c$.

We now take into account the change of the correlation Δ, disregarding for simplicity the potential scattering.

If the alloy is doped with nonmagnetic impurities, the interaction energy of the spins located at the points $\vec{r}$ and $\vec{r}'$ depends on the configuration of the nonmagnetic impurities. If the concentration of the nonmagnetic impurities B is low, then [5]

$$V(r, r') \sim \chi(r, r') = \chi_1(r - r') + \sum_{r_B} \frac{\Delta}{1 - I\chi_1^{loc}} \chi_1(r - r_B)\chi_1(r_B - r'). \tag{9}$$

Here $\chi_1(\vec{r} - \vec{r}')$ differs from the susceptibility $\chi_0(\vec{r} - \vec{r}')$ of the pure metal A because of the difference between the valences of A and B, $\chi_1^{loc} = (2\pi)^{-3}\Omega_0\int\chi_1(k)d^3k$. Since $\chi_1(r) \sim \exp(-r/R)$, the configurations contributing to the susceptibility $\chi(\vec{r} - \vec{r}')$ averaged over the locations of the impurities B are those for which $|\vec{r} - \vec{r}_B| + |\vec{r}_B - \vec{r}'| \approx |\vec{r} - \vec{r}'| + R$. Since $R << (\Omega_0/c)^{1/3}$, the number of such configurations is small, and therefore they do not determine the Curie temperature. For most pairs that determine the Curie temperature, we have $|\vec{r} - \vec{r}_B| + |\vec{r}_B - \vec{r}'| \approx |\vec{r} - \vec{r}'| + b(\Omega_0/c)^{1/3}$, where b is a number on the order of unity and Ω_0 is the volume of the unit cell, i.e.,

$$T_C - T_C^{(1)} \approx T_k^{(1)} \frac{\Delta}{1 - I\chi_1^{loc}} \chi_1(0)\, e^{\frac{-b\,\Omega_0^{1/3}}{c^{1/3}R}}$$

$T_C^{(1)}$ is the transition temperature in the ternary alloy, under the condition that $\Delta = 0$.

If the quantity $1 - I\chi_1^{loc}$ is not too close to zero, then at small c we have $(T_C - T_C^{(1)})/T_C^{(1)} << 1$, i.e., the difference between the electron correlations of atoms A and B has practically no effect on T_C.

We see that the change of T_c due to doping a dilute ferromagnetic alloy with nonmagnetic impurities is large and is directly connected with the average susceptibility if the nonmagnetic impurities change the susceptibility in nonlocal fashion. On the other hand, if the susceptibility changes locally, then this hardly affects T_c even though the average susceptibility may be strongly altered. Measurement of T_c can therefore yield information on the state of the nonmagnetic impurities in such alloys. This question has not yet been answered for a number of alloys.

According to [3], when 6% of tin is added to the alloy Pd + 2%Co, the value of T_c drops from 9.4 to 2.0°K. This is apparently due primarily to the decrease in the density of state, which is connected with the increase in the number of electrons in the d-band (in analogy with the PdAg alloy). The determination of R_0/γ in the PdCo alloy from the dependence of T_c on n ($R_0/\gamma = 3.3$ Å) makes it possible to describe the dependence of T_c on the tin concentration, observed in [3], by using formula (7) and assuming $D \approx 25$, i.e., $F_1 - F_2 \approx 2.5$, which is quite reasonable.

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SUPERCOMPRESSION OF MATTER BY REACTION PRESSURE TO OBTAIN MICROCRITICAL MASSES OF FISSIONING MATTER, TO OBTAIN ULTRASTRONG MAGNETIC FIELDS, AND TO ACCELERATE PARTICLES

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We consider the attainment of very low critical masses of fissioning matter by supercompression with reaction pressure from high-temperature evaporation of matter. It is indicated that such microcritical masses can be used to obtained pulsed streams of neutrons, neutrinos, etc. The possibility is indicated of obtaining ultrastrong magnetic fields ($\gtrsim 10^9$ Oe) by supercompression of matter and acceleration of particles.

Evaporation of matter by powerful radiation and current can result in colossal optical-reaction pressures [1].

Much attention is being paid of late to the idea [2] of increasing thermonuclear yield by superdense compression of hydrogen by optical-reaction pressure.

In this article we propose to use such supercompression of matter to solve two other problems - to obtain microscopic critcal masses of fissioning heavy elements by more effective neutron multiplication accompanying an increase in the density of the fissioning matter, to obtain ultrastrong magnetic field, and to accelerate particles.

1. Obtaining Microcritical Masses of Fissioning Matter

Since the neutron free path prior to multiplication is $\ell_f \approx 1/n_i\sigma_f$, where n_i is the density of the nuclei and σ_f is the cross section of the fission reaction, it follows that increasing the concentration of matter can greatly increase the effective utilization of the fission neutrons, decreasing thereby the critical dimensions $L_{cr} \sim \ell_f \sim 1/n_i$ and the critical masses ($M_{cr} \sim n\ell_f^3 \sim 1/n_i^2$).

Assume that powerful laser radiation acts from all sides on the surface of a particle of fissile material (in many cases it is more convenient and more expedient to have the laser act on a so-called ablation coating - a layer of matter producing the optimal optical-reaction pressure coated on the surface of the fissioning body.