the x-ray beam reflected from the sample moving with mass velocity u = 3.27 km/sec (Fig. 2). The contribution of the second part can be made equal to zero by turning on the x-ray exposure at the instant when the shock wave arrives at the contact boundary of the aluminum and the lithium plate. In the experiment reported here, the x-ray exposure was effected $\sim 0.5 \times 10^{-6}$ sec later, so that the contributions of the two effects to the deflection of the x-ray beam on the explosion picture were approximately equal.

We note in conclusion that the existence, behind the shock-wave front, of a crystalline order sufficient for the registration of x-ray diffraction patterns was confirmed also for the ionic compound LiF in a recent communication [6]. Obviously, the time during which the crystal structure assumes a new equilibrium state is short compared with the employed x-ray exposure times.

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MIXED EXCHANGE INTERACTION IN FCC IRON-PALLADIUM ALLOYS

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The method of small-angle inelastic scattering of neutrons by spin waves, which is based on measuring the limiting scattering angle (θ_0) [1, 2], permits the determination of the sign and magnitude of the exchange-interaction integrals between the different pairs of atoms in alloys. The possibilities of this method were first demonstrated with fcc iron-nickel alloys as an example [2], and the previously proposed [3] antiferromagnetic interaction between the iron atoms was experimentally demonstrated there.

It is known that iron-palladium alloys exhibit properties that are analogous in many respects to those of iron-nickel alloys. In particular, they also have invar properties. It was therefore of interest to study the parameters of the exchange interaction in this system.

We have performed a complete investigation of small-angle inelastic magnetic scattering by spin waves in concentrated iron-palladium alloys with 25, 40, 50, 60, 64, 66, 68 at.% iron. The alloys were smelted with pure components in vacuum and went through a homogenizing annealing for 100 hours. To obtain the disordered state, the alloys were ground into a powder, which was then pressed into tablets of 20 mm diameter and 3 - 5 mm thick. The powders in which the deformation martensite was produced were quenched in oil from 1100°C to obtain a single-phase state. An investigation of the x-ray diffuse background at the location of the superstructure reflection showed that there was no long-range order whatever in the samples. The short-range order, however, remained.

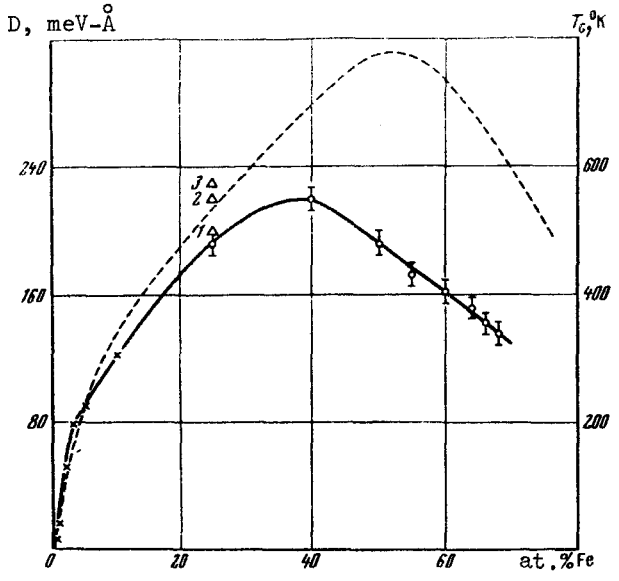

Fig. 1

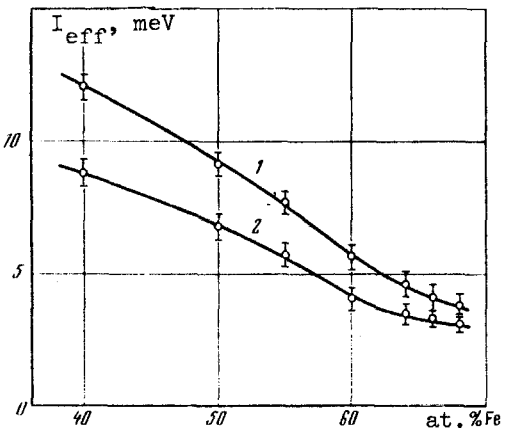

Fig. 2

Fig. 1. Concentration dependence of the coefficient D of iron-palladium alloys: circles - present data, crosses - data of Stringfellow [4], triangles - data of [6] for different degrees of order; 1) η = 0.3, 2) η = 0.5, 3) η = 1.0 (3). The dashed curve is a plot of the Curie point against the concentration according to [7]; like D, the concentration also depends on I_{eff}.

Fig. 2. Dependence of the effective exchange integral on the concentration: 1 - for the experimentally measured atomic spins S_1 = 0.18 and S_2 = 1.4; 2 - for the quantum spins S_1 = 1/2 and S_2 = 3/2.

The neutron investigation was performed with a setup mounted on one of the tangential channels of the IVV-2 reactor. We measured the angular dependence of the difference between the counts of the neutrons scattered from a sample in which the magnetizing field was parallel and perpendicular to the scattering vector. We used a white neutron beam with a divergence on the order of 12 minutes of angle. The fast neutrons were cut off with a quartz filter. The distance between the sample and the counter was of the order of 2.7 m. The counter was moved perpendicular to the optical axis of the setup on a moving stage, the position of which could be fixed accurate to 0.15 minute of angle. The measurements were made at three temperatures (boiling nitrogen, room, and boiling water) and three magnetic fields (2.5, 5.0, and 10 kOe). The limiting angle was estimated from the center of the descending section of the $I_{\parallel - \perp}$ angular dependence. To exclude the influence of the neutron beam divergence, the experimental curve was corrected for the apparatus distortions of the dispersion shape and it was demonstrated that the center of the descending section of the $I_{\parallel - \perp}$ curve correlates well with the sharp descent of the corrected curve.

In approximation where the spin waves have a quadratic dispersion ($E = Dq^2$), the limiting angle θ_0, which does not depend on the neutron scattering wavelength, is connected with the coefficient D as follows:

$$\sin \theta_0 = \frac{\hbar^2}{2m_0 D}, \qquad (1)$$

where m_0 is the neutron mass and q is the wave vector. To calculate D we used the values of θ_0 extrapolated to zero magnetic field and to zero temperature

[2]. The obtained values are shown in Fig. 1 by circles. The crosses in the figure represent the values of D from [4], measured by the same method for alloys with iron concentration up to 10 at.%. The triangles show the values of D for the alloy Pd_3Fe with different degrees of long-range order, calculated in [5, 6] from the magnon-spectrum dispersion curves plotted with a three-crystal spectrometer. We see that our data correlate well with the earlier investigations.

Using only the nearest-neighbor approximation and assuming completely disordered alloys, we can write

$$D = \frac{1}{3} Z R_n^2 I_{\text{eff}} \bar{S} \tag{2}$$

and

$$I_{\text{eff}} \bar{S}^2 = I_{11} S_1^2 (1-c)^2 + 2 I_{12} S_1 S_2 c(1-c) + I_{22} S_2^2 c^2, \tag{3}$$

where $\bar{S} = S_1(1-c) + S_2 c$ and S_1 and S_2 are the atomic spins of palladium (of the first sort) and iron (second sort), I_{11}, I_{12}, and I_{22} are the exchange integrals between atoms located at the closest distances from one another, c is the concentration of the iron atoms, Z is the number of nearest neighbors, and R_n is the radius of the nearest coordination sphere. Expression (2) and (3) make it possible to determine the exchange parameters from the experimentally measured values of D and S.

From the measurement data we calculated the parameters of the exchange interaction for the iron-palladium system by least squares, using the entire series of investigated alloys with the exception of the first one with the lowest iron content. This alloy is apparently closest to the series of low-iron palladium-iron alloys investigated by Stringfellow, and for which formula (3) for I_{eff} does not hold because of the presence of "giant" moments.

The following values of exchange parameters were obtained for the atomic spins $S_1 = 0.18$ and $S_2 = 1.4$ taken from the experimental dependence of the average magnetic moment of iron magnetic alloys, measured by us in [8, 9]:

$$I_{11} = (47 \pm 5)\ \text{meV},\quad I_{12} = (41 \pm 4)\ \text{meV},\quad \text{and}\quad I_{22} = -(1.0 \pm 0.1)\ \text{meV}.$$

If we assume the quantum values of the spins $S_1 = 1/2$ and $S_2 = 3/2$, then the values of exchange parameters become

$$I_{11} = (7.5 \pm 0.5)\ \text{meV},\quad I_{12} = (20 \pm 2)\ \text{meV},\quad \text{and}\quad I_{22} = -(2.1 \pm 0.2)\ \text{meV}.$$

Thus, we have shown here for the first time that mixed ferro- and antiferromagnetic interaction exists between the atoms of concentrated fcc iron-palladium alloys. Just as in iron-nickel alloys, the parameter of the exchange interaction between the iron atoms is negative but smaller in absolute value. The latter fact explains readily why the magnetic moment in Fe-Pd alloys begins to deviate from the mixing law at a higher iron concentration (70 at.%) than in iron-nickel alloys (60 at.%) [10].

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MEASUREMENT OF ELASTIC SCATTERING CROSS SECTIONS IN A GAS BY LASER SPECTROSCOPY METHODS

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1. The main information concerning the interaction potential of particles colliding in a gas has been obtained from studies of the elastic scattering cross sections of atomic and molecular beams. We report here for the first time the measurement of the scattering cross sections by methods of high-resolution laser spectroscopy. We call attention to new features of the behavior of the Lamb dip in molecular gases of low pressure, the nonlinear dependence of its width and shift on the pressure, and the difference between its impact broadening and the Doppler-contour broadening. These features, which are connected with the nature of the scattering of two-level systems, make it possible to separate the contribution of the angular scattering of atoms, and the role of phase-shifting and quenching collisions in the line broadening.

2. In the case of low-pressure gases it is not always possible to identify the impact line width of the spontaneous emission with the Lamb-dip width. The emission line width for collisions is determined by the scattering amplitudes at both levels and was obtained in [1, 2]. To find the width of the Lamb dip it is necessary to solve the kinetic equation for the density matrix in the standing-wave field. The gas-kinetic approach developed in [3] makes it possible to express the departure and arrival terms in this equation through the exact amplitudes for scattering by the levels m and n. In a qualitative study, however, we can use the fact that the width of the Lamb dip in a gas is essentially equal to the time of coherent interaction between the atom and the field. The influence of the collisions on the shape of the Lamb dip will depend essentially on the specific nature of the scattering of the two-level system. Two qualitatively different cases are then encountered.

1) The collisions are accompanied by total loss of the coherence between the levels m and n. In this case the scattering amplitudes for the two levels differ appreciably. The line width of the radiating atom is [1, 2]

$$\gamma = Nv(\sigma_m + \sigma_n) + \gamma_0 , \qquad (1)$$

where σ_m and σ_n are the total elastic cross sections for levels m and n, v is the average velocity of the atoms, N is the density of the scattering centers, and γ_0 is determined by the inelastic scattering at the levels m and n, and also by the line width in the absence of collisions. The width of the Lamb dip is given in this case by (1).