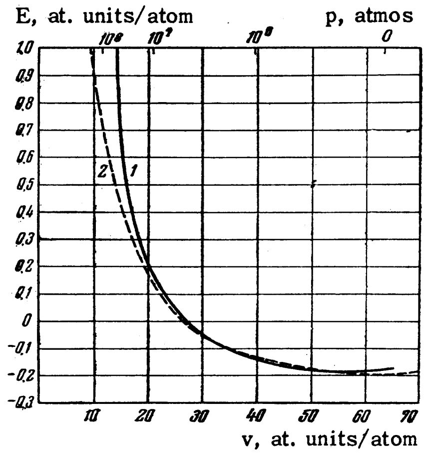
$$E(v) = 93.7 \exp(-1.69 v^{1/3}) - -3.495 v^{-1/3} + 0.582 \text{ at. units/atom.}$$

The pressure is found from the formula $p = -dE/dv$. The equilibrium volume at zero pressure is calculated to be $v_0 = 55$ at. units/atom, and is found experimentally to be $v_0 = 63$. The calculated binding energy, referred to the energy of the free atoms, is 10.0 ev per molecule = 231 kcal/mole. The experimental value of this energy[8] is 242 kcal/mole. At pressures above 5×10^6 atmos the calculated curve 1 lies somewhat higher than curve 2. This might be explained by the onset of an energy storage due to the overlapping of the inner shells. In curve 2 it is only the overlapping of the outer shells which is extrapolated, whereas the calculations for curve 1 automatically take into account the overlapping of the inner shells as well.



I wish to express my thanks to B. I. Davydov for proposing this subject and discussing the results.

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Translated by D. C. West
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EFFECT OF ELECTRIC POLARIZATION ON MAGNETIC PROPERTIES OF FERRITES

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If the spin-orbit interaction of the d electrons in ferrites is taken into account, the effective magnetic permeability becomes a function of the electric polarization of the electron shells of the atoms, i.e., of the dielectric constant. No such dependence is observed at radio frequencies in ferromagnetic metals, owing to the strong polarizability of the conduction electrons.

In certain types of ferrites one can expect the electric properties to affect not only the frequency dependence of the effective permeability, or the width, form, and position of the resonance-absorption line, but also the dependences of these effects on the dimensions and shapes of the specimens, dependences that cannot be accounted for by the method of demagnetizing factors.

The spin-orbit interactions, within the framework of the macroscopic theory, can be accounted for with the aid of the following closed system of equations:

$$\dot{\mathbf{M}} = \gamma \mathbf{M} \times \mathbf{H}_{\text{eff}}; \qquad (1)$$

$$\ddot{\mathbf{P}}_j + \alpha_j \dot{\mathbf{P}}_j + \omega_j^2 \mathbf{P}_j = -(g/c)\, \partial \mathbf{A} / \partial t, \qquad (2)$$

$$\Delta \mathbf{A} = -\frac{4\pi}{c}\left[c \operatorname{curl} \mathbf{M} + \dot{\mathbf{P}} - \frac{1}{4\pi c}\ddot{\mathbf{A}}\right], \qquad (3)$$

$$\mathbf{P} = \sum_j \mathbf{P}_j, \quad \mathbf{H}_i = -4\pi \mathbf{M} + \operatorname{curl} \mathbf{A};$$

$$\mathbf{H}_{\text{eff}} = \mathbf{H} + a M_s^{-2} \Delta \mathbf{M} + \mathbf{H}_i,$$

H is the intensity of the external field, and $aM_s^{-2} \times \Delta\mathbf{M}$ are the fields of the exchange forces. The self-consistent internal field $\mathbf{H}_i$ is due to the spin-spin (source — c curl **M**) and spin-orbit (source — $\dot{\mathbf{P}}$) interactions.

The term **P** in Eq. (2) describes the polarization current due to the change in the electric dipole moment of the atom, a change caused by the vortical electric field due to the magnetization fluctuations. In other words, it is due to the changes in the spatial portion of the wave function of the d electrons, occurring upon change of orientation of the magnetic moments of the electrons.

Equations (2) describe the change in the polarization of a set of interacting atoms with an internal electromagnetic field.

In the work of Ament and Rado,[1] the effective magnetic permeability μ_{eff} is calculated for a ferromagnetic metal having an electric conductivity, and its influence on the width, shape, and position of the resonance line is estimated. For ferromagnetic conductors placed in a radio-frequency field, the displacement and polarization currents can be neglected, as was done in Ref. 1. For ferrites, this cannot be done in general, and therefore Eq. (3) takes these currents into account.

Using the original system of equations to solve the boundary problem for a half-space filled with ferrite, in the case of a plane wave normally incident on the boundary, we obtain, in analogy with the procedure given in Ref. 1, the impedance Z = [μ_{eff}/ϵ_{eff}], where according to (2) and (3)

$$\varepsilon_{eff} = \varepsilon' - i\varepsilon'' = 1 + 4\pi \sum_i g_i (\omega_j^2 - \omega^2 + i\omega\alpha_j)^{-1}. \quad (4)$$

Then

$$\mu_{eff} = \frac{\eta - \Omega^2 + 2i(a\omega^2/2\pi M_s^2 c^2)^{1/2}(\varepsilon' - i\varepsilon'')^{1/2}}{[\eta - \Omega^2 + i(a\omega^2/2\pi M_s^2 c^2)^{1/2}(\varepsilon' - i\varepsilon'')^{1/2}]^2}. \quad (5)$$

Here η and Ω stand for the same quantities as in Ref. 1, and the quantity a is denoted in Ref. 1 by A.

It follows from (5) that the electric polarization of the ferrite is accounted for by a shift of the resonant frequency and to a broadening of the resonance-absorption line.

The results by Ament and Rado are contained in Eq. (5). In fact, the conduction current can be taken into account by putting j = 0 in (4), for the case of the free electrons. Then $\omega_0 = 0$, α_0 is the frequency of collision between the electrons and the lattice, and $4\pi g_0$ is the square of the Langmuir frequency. Now $\sigma = g_0/\alpha_0$ is the static value of the electron conductivity. In metals $\sigma/\omega \gg 1$, and $\omega \ll \alpha_0$, and therefore (5) changes into (31b) of Ref. 1.

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Translated by J. G. Adashko
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CROSS SECTIONS FOR INTERACTION OF PI MESONS WITH CARBON NUCLEI

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In the optical model of the nucleus, scattering and absorption of particles is described as the motion of these particles in the field of a complex potential. A considerable part of the work done on the optical model is devoted to a determination of the complex potential or of uniquely-related parameters which provide best agreement with experimental data on the interaction of fast particles with nuclei. In a number of other analyses[1,2] it was sought to relate these parameters, which characterize the interaction of fast particles with nuclei, to the scattering cross sections and amplitudes for elementary particles. In particular, Frank, Gammel, and Watson[1] have obtained formulas relating the complex potential of the optical model to the amplitude of the forward scattering of mesons against nucleons, averaged over the protons and neutrons of a nucleus,* and have calculated the values of the real and imaginary parts of the potential, and thus of the mean free path λ_t of mesons in nuclear matter at energies of 0 to 350 Mev. This data will be used in the present article to calculate the total effective cross sections for elastic and inelastic interactions of π mesons with carbon nuclei in this energy region. The computations are carried out according to the formulas of the quasi-classical approximation.[4,5]

$$\sigma_{el} = \pi\lambda\!\!\!^{-2} \sum_{l=0}^{l\leqslant R/\lambda\!\!\!^{-}} (2l+1)\,|\,1 - \exp\{[-K + 2ik(n-1)]\,s_l\}\,|^2, \quad (1)$$

$$\sigma_{inel} = \pi\lambda\!\!\!^{-2} \sum_{l=0}^{l\leqslant R/\lambda\!\!\!^{-}} (2l+1)\,[1 - \exp(-2Ks_l)], \quad (2)$$
$$s_l = (R^2 - l^2\lambda\!\!\!^{-2})^{1/2},$$

where $\lambda\!\!\!^{-} = k^{-1}$ is the wavelength of the incident mesons; $K = \lambda_t^{-1}$ is the absorption coefficient and n is the index of refraction of nuclear matter; R is the nuclear radius taken to be $1.4A^{1/3} \times 10^{-13}$ cm, which gives for carbon 3.2×10^{-13} cm. In order to estimate the error of the quasi-classical approximation, the cross sections were also calculated according to the exact quantum mechanical formulas:[5]

$$\sigma_{el} = \pi\lambda\!\!\!^{-2} \sum_{l=0}^{\infty} (2l+1)\,|\,\beta_l - 1\,|^2, \quad (3)$$

$$\sigma_{inel} = \pi\lambda\!\!\!^{-2} \sum_{l=0}^{\infty} (2l+1)\,(1 - |\,\beta_l\,|^2), \quad \beta_l = e^{2i\delta_l}, \quad (4)$$

*The real part of the forward-scattering amplitude was obtained in Ref. 1 from dispersion relations.[3]