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54

ON THE THEORY OF MAGNETIC SUSCEPTIBILITY OF METALS

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RECENTLY, the magnetic susceptibility of an electron gas was calculated by several authors,[1-3] taking into account long-range Coulomb correlation. However, only the susceptibility due to the Fermi branch of the excitation spectrum was taken into account there. We would like to direct attention to the fact that the (Bose) plasma-oscillation quanta also make a definite contribution to the susceptibility. Actually, although these excitations are neutral and give no contribution to the current, their energy depends on the magnetic field intensity H and consequently the plasma quanta are "carriers of magnetism." At ordinary temperatures, real plasma quanta in a metal are practically not excited; their zero-point energy, however, also depends on H. This leads, as we shall show, to plasma diamagnetism comparable to the Landau diamagnetism.

As is known (see, for example, Ref. 4), a separation of plasma oscillations into longitudinal and transverse is still possible in a weak magnetic field. For our problem, only the former are of interest; the frequency of a longitudinal plasma quantum (in the frame of an isotropic model) is

$$\omega^2 = \omega_L^2 + \omega_H \sin^2\alpha + O(k^2), \qquad (1)$$

where $\mathbf{k}$ is the wave vector of a plasmon, α is the angle between $\mathbf{k}$ and H, $\omega_L^2 = 4\pi ne^2/m$, $\omega_H = eH/mc$, and n and m are the concentration and effective mass of the electrons ($\omega_H \ll \omega_L$). We shall disregard terms of order k^2 in Eq. (1) (apparently, they are small in comparison with ω_L^2 for all k up to the limiting wave number k_0).

The magnetic susceptibility per unit volume, due to the dependence of the zero-point energy of the plasma on the magnetic field, is:

$$\chi = -\frac{1}{2}\frac{\hbar}{(2\pi)^3}\frac{\partial^2}{\partial H^2}\int\limits_{k\leqslant k_0} d\mathbf{k}\,\omega(\mathbf{k}). \qquad (2)$$

By virtue of Eq. (1), this yields

$$\chi = -(1/18\pi^2)(e^2/mc^2)(\hbar/m)k_0^3/\omega_L. \qquad (3)$$

The quantity k_0 in our approximation (small H) can be regarded as independent of the magnetic field. Setting $\hbar k_0 = \beta p_F$, where p_F is the Fermi boundary momentum and β is a dimensionless parameter (which may depend on n) we obtain

$$\chi = -(\beta^3/12\sqrt{\pi})(\hbar/mc)(ne^2/mc^2)^{1/2}$$
$$= -0.96\cdot 10^{-18}(m_0/m)^{3/2}\beta^3\sqrt{n} \qquad (4)$$

(m_0 is the mass of a free electron). Inasmuch as $\beta < 1$, but evidently $\beta > \frac{1}{2}$,[5] $|\chi| \sim 10^{-6} - 10^{-7}$. This quantity can be fully comparable with the result of Pines, obtained in disregarding the zero-point energy of the plasma. Hence it is clear that this neglect, generally speaking, is by no means justified and the quantiative comparison of Pines' theory with experiment must be reviewed.

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55

THE PROPERTIES OF THE GREEN FUNCTION FOR PARTICLES IN STATISTICS

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IN an attempt to apply the methods which have recently been developed in quantum electrodynam-