The kernel in the right side of (6) is spherically symmetrical, so that $\tilde{\Phi}$ and ψ correspond to definite values of the angular momentum. Since the right side of (9) is also positive definite, bound state with all values of the angular momentum should exist at $\alpha \to \infty$.

If we estimate the right side of (9) by using single-parameter approximations with the aid of the functions of the three-dimensional oscillator (1s for ψ_0 and 1s and 2p for f), then the binding energy turns out to be 0.13ω and 0.11ω for the s- and p-states of the complex, respectively. This should be observable experimentally; we note that nearly equal values of the binding energy of exciton-phonon complexes were recently measured experimentally in [4].

In the case of weak coupling ($\alpha << 1$) the main contribution to the proper energy part at energies close to ω is made by the infinite set of diagrams shown in the figure. An analysis of the equation for the vertex part shows that in this case there are no bound states, but in a strong magnetic field, when the cyclotron frequency ω_c is nearly equal to ω, the complexes are produced. This is precisely the nature of the "magneto-optic onomaly" [5]. The mechanism whereby it occurs, due to the resonance polarizability, is close to that considered in [6].

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PARAMAGNETIC ABSORPTION OF ULTRASOUND (US) BY CONDUCTION ELECTRONS IN A QUANTIZING MAGNETIC FIELD

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Submitted 9 June 1969
ZhETF Pis. Red. 10, No. 2, 98 - 101 (20 July 1969)

At sufficiently low temperatures, the main mechanism of US absorption in metals is its interaction with the conduction electrons. In the case of high US frequencies $\omega >> \tau^{-1}$ (τ is the electron relaxation time), an appreciable role is played in its absorption by the spatial dispersion of the electric conductivity tensor σ. When US passes along a quantizing magnetic field H, giant quantum absorption oscillations are produced (when H is varied), as well as oscillations of the propagation velocity [1]. In this communication we study the contribution of the spin system of an electron fluid to the absorption of transversely polarized US propagating along H.

In real metals, the energy of the spin splitting of the electron levels $\hbar\Omega_0$ usually does not coincide with the energy $\hbar\Omega$ of the cyclotron quantum. This can give rise, in addition to ordinary giant quantum oscillations, also to new peaks caused by the absorption of the US by the spin system of the electrons. The positions of these peaks, as functions of the US wave vector k and of H, are given by the equation

$$E_{n,\,p^{\pm}(k,\,\Omega_0)} = \zeta^{\pm}, \tag{1}$$

where $E_{n,p}$ are the eigenvalues of the electron in the magnetic field (n - oscillator quantum number, p - electron momentum along H), and $p^{\pm}(k, \Omega_0) = \hbar k/2 + m(\omega^{\mp}\Omega_0)/k$, where m is the electron mass; the upper sign (+) corresponds to a right-hand circularly polarized wave, and (-) correspond to left-hand polarization; $\zeta^{\pm} = (\zeta \pm \hbar\,|\Omega_0|/2)$ in formula (1) is taken with a + or - sign for right- and left-hand polarizations, respectively. The peaks of the ordinary giant oscillations of absorption are given by

$$E_{n,\,p^{\pm}(k,\,\Omega)} = \zeta^{+}, \qquad E_{n,\,p^{\pm}(k,\,\Omega)} = \zeta^{-}. \tag{2}$$

From the equation of motion of the lattice interacting with the electrons via the self-consistent field, from Maxwell's equations, and from the equation for the density matrix we get the following dispersion equation

$$G^{\pm}(\omega, k) = 4\pi i\ [\frac{\omega}{c^2k^2}\ \mathrm{Re}\,\sigma^{\pm} - \mu_0\ \mathrm{Im}\,\chi^{\pm}/(1-\psi\,\mathrm{Re}\,\chi^{\pm})^2 + (\psi\,\mathrm{Re}\,\chi^{\pm})^2, \tag{3}$$

in which

$$G^{\pm}(\omega, k) = 1 + 4\pi\,[\mathrm{Re}\,(\frac{\mu_0^2\,\chi^{\pm}}{1-\psi\chi^{\pm}}) + \frac{\omega}{c^2k^2}\ \mathrm{Im}\,\sigma^{\pm}] + \frac{\omega^2\,\omega_{02}^2}{c^2k^2\,(\omega^2 - v_0^2k^2 + \omega\Omega_p)};$$

$$\sigma^{\pm} = \sigma_{xx} \pm i\sigma_{yx} = -\frac{N_e e^2}{i\omega m}\{1 + \frac{\hbar\Omega}{N_e}\sum_{(n,p,p_y,\sigma)}(n+\frac{1}{2} \pm \frac{1}{2})\frac{f^{\sigma}_{n\pm1,\,p-\hbar k} - f^{\sigma}_{n,p}}{E_{n\pm1,\,p-\hbar k} - E_{n,p} + \hbar\omega + i\gamma},$$

$$\chi^{\pm} = 2\sum_{n,p,p_y}\frac{f^{\pm}_{n,\,p-\hbar k} - f^{\pm}_{n,p}}{E_{n,\,p-\hbar k} - E_{n,p} + \hbar(\omega \pm \Omega_0) + i\gamma}; \quad \gamma \to +0,$$

where ω_{02} is the Langmuir frequency of the lattice ions, Ω_p is their cyclotron frequency, v_0 is the speed of sound in the absence of a self-consistent field, μ_0 is the magnetic moment of the free electron, N_e is the electron density, and finally $f^{\pm}_{n,p} = f(E_{n,p} - \zeta^{\pm})$ is the Fermi function. The Fermi-liquid action is taken into account, as in [3], with the aid of a single constant ψ. It follows from (3) that when $\psi\ \mathrm{Re}\ \chi^{\pm} \gg 1$ the contribution of the spin system to the US absorption decreases appreciably compared with the case when the Fermi-liquid interaction plays no role ($\psi = 0$).

Assuming that $\mathrm{Im}\omega = \gamma \ll \mathrm{Re}\omega = \omega'$, we obtain an equation for the spectrum

$$G(\omega', k) = 0. \tag{4}$$

This equation describes the coupled acoustic, quantum, electromagnetic [2], and helical waves with a damping decrement

$$\gamma^{\pm}(\omega', k) = \gamma_e^{\pm} + \gamma_\mu^{\pm}, \qquad (5)$$

$$\gamma_e^{\pm} = \gamma_o^{\pm} \sum_{n,\sigma} (n \pm 1/2 + 1/2)\,[f^{\sigma}(E_{n,p^{\pm}(k,\Omega)} - \hbar\omega) - f^{\sigma}(E_{n,p^{\pm}(k,\Omega)})]^3,$$

$$\gamma_\mu^{\pm} = \gamma_o^{\pm} \sum_n (ak)^2 \left(\frac{\Omega_o}{\Omega}\right)^2 [f^{\pm}(E_{n,p^{\pm}(k,\Omega_o)} - \hbar\omega) - f^{\pm}(E_{n,p^{\pm}(k,\Omega)})],$$

$$\gamma_o^{\pm} = -\left(\frac{\partial G}{\partial \omega}\right)^{-1} e^2 (mc^2 a^4 k^3)^{-1}, \qquad a^2 = c\hbar/|e|H.$$

If we neglect the influence of the self-consistent fields on the US spectrum then we can put $\omega \approx v_0 k$ in (5). Equation (6) then describes the US damping decrement. It follows from (5) that when $\omega \ll \Omega$ or Ω_0, the absorption of sound exists only for waves with $k > k_{min}(\Omega_0) \sim \Omega_0\sqrt{m/2\zeta}$ (the first term in (5)) and $k > k_{min}(\Omega_0) \sim \Omega_0\sqrt{m/2\zeta}$ (second term in (5)). $\gamma_\mu^{\pm}$ is due to the interaction of the US with the electron spins responsible for the Pauli paramagnetism. The absorption maxima $\gamma_e^{\pm}$ and $\gamma_\mu^{\pm}$ are shifted because of the difference between Ω_0 and Ω.

If $\hbar\omega' \ll T$, the difference between the Fermi functions in (5) can be replaced by the derivative, and it is then obvious that the positions of the maxima of the US absorption oscillations are determined by Eqs. (1) and (2). The conditions necessary for the experimental observation of the oscillations of the paramagnetic absorption of ultrasound is given by the equations

$$\hbar\Omega,\ \hbar\Omega_o \gg T,\ \hbar/\tau,$$

$$|\Omega - \Omega_o| > \omega \gg (mv_o^2/\hbar\tau)^{1/2}.$$

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PLASMA DIFFUSION IN STELLARATORS

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Submitted 12 June 1969
ZhETF Pis. Red. 10, No. 2, 101 - 105 (20 July 1969)

As is well known, in many stellarators anomalous leakage of plasma is observed in a wide range of plasma-parameter variation [1 - 4]. The cause of the anomalous diffusion is not clear at present. On the one hand, plasma in toroidal systems is subject to a wide class of dirft instabilities (cf., e.g., [5] and the literature cited there), and some experiments [4, 7] the observed leakage can be related to oscillations in the drift-frequency range. On