The results of experimental observation of sound excitation in Ag single crystals under the conditions described above were published recently [4]. Oscillations periodic in H_0^{-1} were observed, but vanished at $H_0 \parallel E$ and with increasing temperature, and there was no temperature dependence of u in weak fields. All this agrees qualitatively with our results. It is noted in [4] that the oscillations are not due to geometric resonance for Γ, and in particular u and Γ differ slightly in phase. In our opinion, it is desirable to perform experiments with an essentially nonspherical Fermi surface, where considerable differences between u_{osc} and Γ_{osc} can be expected both in magnitude and in phase.

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ANOMALOUS DISSIPATION AND PENETRATION OF STRONG ELECTROMAGNETIC RADIATION INTO A BOUNDED PLASMA

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We consider the stationary picture of penetration of a transverse wave with frequency close to the plasma frequency into a bounded plasma. The parametric growth of the longitudinal noise leads to a considerable increase of the effective collision frequency and to a decrease of the wave penetration in comparison with the usual "collision" values.

Anomalous absorption of an electromagnetic field in a plasma was experimentally observed relatively recently [1 - 3]. Theoretically, such a phenomenon can be produced by the parametric excitation predicted by Silin [4], of longitudinal oscillations in a plasma placed in a high-frequency electric field. Unlike [5 - 8], which dealt with the stationary turbulent state resulting from the development of a parametric instability in a homogeneous plasma under the influence of a homogeneous electric field, we consider here the stationary picture of the penetration of a transverse wave into a semi-bounded plasma (z > 0) with allowance for emergence of the excited longitudinal oscillations in the inhomogeneous field of the pump wave. We investigate the normal incidence of a transverse wave of frequency ω_0 close to the plasma frequency ω_p. The parametric interaction of the plasma with ion-acoustic oscillations, which arises under the influence of a strong electromagnetic field of an incident wave, occurs only in the region near the boundary, where the amplitude of the penetrating field is large enough (the interaction region). On emerging from the interaction region, the parametrically growing plasma noise and ion-acoustic noise carries the energy of the external field out of the region of its localization. The external-field energy then goes over into longitudinal-noise energy and the amplitude $E_0(z)$ of the transverse wave decreases with increasing distance from the boundary. Such a decrease is irreversible, since the number of excited waves in the considered case of strong excess above threshold turns out to be quite large.

The region of external-field localization is determined by the distance over which the energy flux of the external field becomes comparable with flux of the parametrically growing longitudinal noise. Accordingly, the depth of penetration L of the pump wave is given by

$$L = \frac{1}{2\kappa}\ln(S^{tr}/S^{\ell}), \quad S^{tr} > S^{\ell} . \tag{1}$$

Here κ is the maximal value of the spatial growth increment $k''(\omega, \vec{k}_{\parallel})$ of the ion-acoustic and plasma waves, determined from the solution of the dispersion equation for the quantity $k_z \equiv k_z'(\omega, \vec{k}_{\parallel}) - ik_z''(\omega, \vec{k}_{\parallel})$

$$\epsilon(\omega, k_{\parallel}, k_z)\epsilon(\omega - \omega_o, k_{\parallel}, k_z - k_o) = \frac{1}{4}\frac{(k_{\parallel} r_E)^2}{k_{\parallel}^4 r_{De}^4};$$

$$k_{\parallel} >> |k_z|, k_o; \omega_o >> \omega > 0; \quad k_o = \frac{1}{c}\sqrt{\omega_o^2 - \omega_p^2}; \tag{2}$$

$\varepsilon(\omega, \vec{k}_{\parallel}, k_z = \varepsilon' + i\varepsilon''$ is the linear longitudinal dielectric constant, $\vec{r}_E = e\vec{E}_0/m_e\omega_0^2$ is the amplitude of the oscillations of the electrons in the field of the transverse wave, E_0 is the amplitude of the transverse wave in the plasma near the boundary, $\vec{k}_{\parallel}$ is the projection of the wave vector on the plasma boundary, $S^{tr} = k_0c^2E_0^2/4\pi\omega_0$ and S^{ℓ} are the energy fluxes of the transverse wave and of the Langmuir noise in the plasma, the longitudinal-oscillation flux corresponding to the integral of the domain of wave numbers $k_{\parallel}$ and frequencies ω at which the increment $k_z''(\omega, \vec{k}_{\parallel})$ is maximal. In the derivation of (2) it was assumed that the condition $k_0L > 1$ and the inequality

$$\kappa^2 r_{De}^2 << \omega_s/\omega_o$$

which makes it possible to neglect the contribution of harmonics of frequency $\omega + \omega_0$ are satisfied. At sufficiently high external-field intensities we obtain from (2) the following equation for κ:

$$\kappa = \frac{1}{4}\sqrt[4]{\frac{3}{4}}\frac{k_{\parallel,r}\sqrt{r_E^2 - r_{E,\text{thr}}^2}}{q_s r_{De}^2}; \qquad k_o\frac{q_p^2}{q_s^2} < \kappa < q_s, k_o$$

$$q_p^2 = -\frac{1}{3r_{De}^2}\epsilon''(\omega - \omega_o, k_{\parallel,r}); \quad q_s^2 = k_{\parallel,r}^4 r_{De}^2\epsilon''(\omega, k_{\parallel,r}). \tag{3}$$

Here $k_{\parallel,r}$ is determined from the condition

$$\omega_o = \omega_s + \omega_p(1 + \frac{3}{2}k_{\parallel,r}^2 r_{De}^2), \quad \omega_s = \omega_{Li} k_{\parallel,r} r_{De},$$

and $E_{0,\text{thr}}$ is the threshold intensity (see formula (4.17) of [9]). In this case we can write for the energy flux of the Langmuir wave the following expression

$$S^{\ell} = (2\pi)^{-3}Wv_{\text{lim},p}^z\Delta^3 k; \quad \Delta^3 k = k_{\parallel,r} r_{De}\kappa^2 q_s\frac{v_{Te}}{v_s},$$

$$v_{\text{lim},p}^z = 3v_{Te}r_{De}(k_o - k_z') \approx \sqrt{3}v_{Te}r_{De}\kappa \tag{4}$$

Here $W \simeq T_e$ is the spectral energy density of the thermal plasma noise, and $\Delta^3 k$ is the phase-volume element of the plasma oscillations in the region $k_z'' \simeq \kappa$.

The depth of penetration (1) determined above can be set in correspondence with an effective conductivity σ_{eff} and a collision frequency ν_{eff}

$$\sigma_{eff} \approx \frac{\nu_{eff}}{4\pi} \approx \frac{k_0 c^2}{4\pi \omega_0 L}. \quad (5)$$

We note that since the noise energy increases slowly over the length of the transverse wave, then the coefficient of reflection of this wave from a plasma with a sharp boundary is determined by the usual formulas of the linear theory [10]. In the case of wave reflection from an opaque weakly-inhomogeneous plasma, when the characteristic dimension of the inhomogeneity exceeds L, the wave field intensity decreases to $E_{0,thr}$ in the transparency region and the wave reflected from a dense plasma has an amplitude $E_{0,thr}$. Thus, the reflection coefficient is a small quantity of the order of $E_{0,thr}^2/E_0^2$.

In conclusion, let us estimate the effective conductivity under conditions that can exist in experiments on laser heating of a plasma. Thus, for example, for a hydrogen plasma of density $n_e \simeq 10^{21}$ cm^{-3}, an electron temperature $T_e \simeq$ 16 keV, a non-isothermy $T_e/T_i \gtrsim 12$, a neodymium-laser emission frequency $\omega_0 =$ 1.78×10^{15} sec^{-1} and a field intensity $E_0 \lesssim 6 \times 10^8$ V/cm we have in accord with formulas (3), (4), and (5)

$$\nu_{eff}/\nu_{ei} \approx 5 \cdot 10^{-6} E_0 \quad (6)$$

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