corresponding curve for Hg^{2+}. However, the relative yields of differently charged ions are closer in case of Xe^+ and Hg^+ than for Kr^+. Starting with the production of triply charged ions, the ionization cross sections for large E_2 decrease by a factor of approximately 4—5 with detachment of each succeeding electron from the singly-charged ion. The curves have been plotted with account of the background observed for masses corresponding to the detachment of one electron with the electron gun turned off, amounting to approximately 10—15 percent of the peak produced by the ionization of the ions with the electrons at $E_2 = 250$ eV.

The cross sections for single ionization of singly-charged ions increase sharply when the energy E_1 of the electrons in the ion source is increased by 15 eV starting with 1—3 eV above the potential for the appearance of the corresponding doubly-charged ions. These results lead to the assumption that the ion beam contains several groups of ions with large metastable excitation. Such ions can appear as a result of the ionization of the atoms from the internal orbits. A value of $\sim 10^{-15}$ cm^2 for the effective cross section of single ionization of Kr^+ at the maximum of the ionization curve, estimated in our experiments accurate to within a factor of 1.5, is therefore not unexpected. The cross section for the production of doubly charged ions upon ionization of singly charged ions is 5—10 times larger than for ionization of the corresponding atoms. The cross sections for the production of ions of equal charge multiplicity but more than doubly charged, by collision between high-energy electrons and Hg^+, Xe^+, and Kr^+ ions agree with those obtained by collision with the corresponding atoms, accurate to within a factor of 1.5—2.

We present the relative effective cross sections σ_{max} for single ionization of different ions in the region of the maximum for the ions investigated by us (the energy E_1 of the electrons was 150 eV):

	Hg^+	Xe^+	Kr^+	Ar^+	Ne^+	Hg^{2+}	Xe^{2+}	Kr^{2+}
σ_{max}:	1.0	1.4	1.8	0.3	0.1	1.3	1.5	0.4

The error in the determination of the relative cross sections is ± 30 percent, with the exception of the ionization Ar^+ and Ne^+, for which the error can reach ± 50 percent. It is seen from these data that in the case of ionization of ions with many electrons the value of the effective cross section for single ionization depends little on the charge multiplicity of the initial ion. The cross section for the ionization of singly charged ions is larger for ions with a large number of electrons.

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[1)]Smooth curves have been drawn through the experimental points although in some cases kinks can be seen, for example for the production of Hg^{2+} ions with $E_2 \sim 60$ eV.

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137

ONE POSSIBILITY OF PLASMA INSTABILITY

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KINETIC instability of a plasma occurs when the higher-energy levels are more probable. For the Cerenkov and cyclotron buildup of the field oscillations, inversion in the population of levels is actually necessary for the particles whose velocity is close to the field oscillation phase velocities. In the present paper we wish to indicate another possibility for the instability of plasma. This possibility is also connected with inversion in population of the particle levels, but for velocities which can differ substantially from the phase velocities of the field oscillations.

As is well known, the rate of change in the number of quanta $N_{\mathbf{k}}$, caused by their scattering on the particles, is given by the formula:

$$\begin{aligned}\frac{dN_{\mathbf{k}}}{dt} = 2\pi\hbar \sum_{l,p} |V(\mathbf{k},\mathbf{l})|^2 \{[(N_{\mathbf{k}}+1) f(\mathbf{p}+\hbar\mathbf{q})(1-f(\mathbf{p}))\\ \times N_{\mathbf{l}} N_{\mathbf{k}}(N_{\mathbf{l}}+1) f(\mathbf{p})(1-f(\mathbf{p}+\hbar\mathbf{q}))]\\ \times \delta(E_{\mathbf{p}+\hbar\mathbf{q}} - E_{\mathbf{p}} - \hbar\omega_{\mathbf{k}} + \hbar\omega_{\mathbf{l}}) + [(N_{\mathbf{k}}+1)(N_{\mathbf{l}}+1)\\ \times f(\mathbf{p}+\hbar\mathbf{q}')(1-f(\mathbf{p})) - N_{\mathbf{k}} N_{\mathbf{l}} f(\mathbf{p})(1-f(\mathbf{p}+\hbar\mathbf{q}'))]\\ \times \delta(E_{\mathbf{p}+\hbar\mathbf{q}'} - E_{\mathbf{p}} - \hbar\omega_{\mathbf{k}} - \hbar\omega_{\mathbf{l}})\}, \qquad (1)\end{aligned}$$

where $f(\mathbf{p})$ is the particle distribution function and $\mathbf{q} = \mathbf{k} - \mathbf{l}$ and $\mathbf{q}' = \mathbf{k} + \mathbf{l}$.

For plasmas which are of practical interest, it is often possible to disregard the quantum effects (naturally, this does not mean that the instability discussed below is impossible in quantum systems). Then (1) can be written in the form:

$$\frac{dW_{\mathbf{k}}}{dt} = 2\pi \sum_{l} |V(\mathbf{k}, \mathbf{l})|^2 \{- W_{\mathbf{k}} W_{\mathbf{l}} [\psi(\omega_{\mathbf{k}} - \omega_{\mathbf{l}}, \mathbf{k} - \mathbf{l}) + \psi(\omega_{\mathbf{k}} + \omega_{\mathbf{l}}, \mathbf{k} + \mathbf{l})] + (W_{\mathbf{l}} - W_{\mathbf{k}}) \varphi(\omega_{\mathbf{k}} - \omega_{\mathbf{l}}, \mathbf{k} - \mathbf{l}) + (W_{\mathbf{l}} + W_{\mathbf{k}}) \varphi(\omega_{\mathbf{k}} + \omega_{\mathbf{l}}, \mathbf{k} + \mathbf{l})\}. \quad (2)$$

Here

$$W_{\mathbf{k}} = \hbar N_{\mathbf{k}}, \qquad \varphi(\omega, \mathbf{k}) = \int d\mathbf{p} f \delta(\omega - \mathbf{k}\mathbf{v}),$$

$$\psi(\omega, \mathbf{k}) = -\int d\mathbf{p} \delta(\omega - \mathbf{k}\mathbf{v})(\mathbf{k}\partial f/\partial \mathbf{p}). \quad (2')$$

An increase of $W_{\mathbf{k}}$ with time can signify a transfer of oscillation energy from one spectral region to another. This is connected with the positiveness of the function $\omega\psi$. The function $\omega\psi$ can also assume negative values. In the latter case, the amplitude of oscillation of sufficiently high intensity increases in time. The physical process causing such buildup of oscillations is the scattering of the oscillations by the particles.

We should note that, the function $\omega\psi(\omega, \mathbf{k})$ is negative also for the kinetic plasma instability connected with the reverse Cerenkov effect. The arguments of the function ψ are then the frequency and wave vector of the plasma oscillation. The essential difference from the possible plasma instability under discussion here lies in the fact that in our case the arguments of the function ψ are the sum or difference of the frequencies and wave vectors of two plasma waves. For example, in the case of high-frequency and comparatively rapid waves, instability can thus develop at relatively low velocities given by the relationship:

$$\mathbf{v}(\mathbf{k} - \mathbf{l}) = \omega_{\mathbf{k}} - \omega_{\mathbf{l}}. \quad (3)$$

In other words, the instability under discussion calls for inversion in the level population of the particles taking part in the scattering, for which the following laws of conservation are fulfilled

$$h\omega_{\mathbf{k}} + E_{\mathbf{p}} = \hbar\omega_{\mathbf{l}} + E_{\mathbf{p}'}, \qquad \mathbf{k} + \mathbf{p} = \mathbf{l} + \mathbf{p}'. \quad (4)$$

It is obvious that formula (3) is the classical limit for the conservation laws (4). The following interesting consequence follows from formula (3): slow currents in the plasma can be unstable with respect to buildup of comparatively rapid waves.

For a plasma in a magnetic field with an inhomogeneous spatial distribution of the Larmor orbits, the instability will be characterized by the function

$$\psi_{ij}^{(n)}(\omega, \mathbf{k}) = \int d\mathbf{p} \delta\left(\omega - \frac{k_x v_\perp^2}{2\Omega^2}\frac{d\Omega}{dy} - n\Omega - k_z v_z\right) \times F_i(n, \mathbf{k}) F_j^*(n, \mathbf{k}) \left(k_z \frac{\partial f}{\partial p_z} - \frac{n\Omega}{v_\perp}\frac{\partial f}{\partial p_\perp} - \frac{ck_x}{eB}\frac{\partial f}{\partial y}\right).$$

Here

$$F_x(n, \mathbf{k}) = \frac{v_\perp}{k_\perp}\left[ik_y J_n'(\xi) - k_x \frac{n}{\xi} J_n(\xi)\right],$$

$$F_y(n, \mathbf{k}) = \frac{v_\perp}{k_\perp}\left[- ik_x J_n'(\xi) - k_y \frac{n}{\xi} J_n(\xi)\right], \qquad F_z = v_z J_n(\xi),$$

n is an integer, $\Omega = eB/mc$ is the Larmor frequency, the z axis is directed along the magnetic field, $v_\perp^2 = [\mathbf{B} \times \mathbf{v}]^2/B^2$, and $\xi = k_\perp v_\perp/\Omega$.

It is clear that the instability in question against buildup of electromagnetic oscillations can occur not only in a plasma, but also in every medium where inversion in level population occurs. It may be necessary here to make a quantum investigation of stability conditions. However, none of this changes the important feature of such an instability, namely the need for a large oscillation amplitude, since the instability is apparently possible only in an essentially nonlinear perturbation mode.

A detailed analysis of the possibilities for such an instability would entail an examination of a whole series of additional dissipative processes—which we have not mentioned at all in this paper—and also a detailed study of the excitable spectra. This lies outside the scope of the present report, in which we wish to draw attention to the principal possibility of the instability under discussion.

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138