WAVES SCATTERING PROCESSES IN AN INHOMOGENEOUS PLASMA WITH UPPER HYBRID PUMP

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1. It is well known that investigations of electromagnetic waves scattering processes are very important for studying such problems as plasma diagnostics, wave transformation mechanism in plasma, definition of dispersion properties of plasma were processes, measurement of the HP pump power dissipation etc.

In previous works [1,2] the waves scattering processes in homogeneous plasma subjected by lower hybrid and upper hybrid radiation and in [3] the plasma with density gradient in the presence of an lower hybrid pump waves.

In the present report the scattering of electromagnetic wave by density fluctuations in an inhomogeneous magnetoactive plasma in the presence of paramentic decay instability of a upper-hybrid wave is investigated. The pump wave frequency lives in the lower hybrid frequency region.

We then suppose that electron-ion plasma imbedded to the magnetic field $B_0 = B_0 \vec{Z}$ and pump wave electric field $E_0 = E_0 \vec{y} \cos \omega_0 t$ excites electron drift waves $\omega_{De} = -k_\perp \alpha T_e / m_e \Omega_e$, where $\alpha = \left(\dfrac{1}{n_e} \right) \dfrac{dn_e}{dy}$ is the plasma inhomogencity parameter. We can write the different cross section in the form (see monography A.I. Akhiezer et. al., Plasma Electrodynamics, Pergamon Press, 1975):

$$d\Sigma = \frac{1}{2\pi} \left(\frac{e^2}{mc^2} \right)^2 \frac{\omega'^2 \omega''^2}{\omega_{pe}^4} R |\xi|^2 \left\langle \delta n_e^2 \right\rangle_{\Delta\omega, \vec{q}} d\omega'' do , \qquad (1)$$

where $\Delta\omega = \omega' - \omega''$, $q = \vec{k}' - \vec{k}''$, $\vec{k}'$, $\vec{k}''$ *and* ω', ω'', are the frequencies and the wave vectors of the incident and scattered waves, o is the space angle, $\left\langle \delta n_e^2 \right\rangle_{\Delta\omega, \vec{q}}$ is the correlator of the electron density fluctuations at the combination frequency $\Delta\omega$.

We consider the decay of the pump wave ω_0 into upper hybrid wave $\omega_H = \Omega_e \left(1 + \dfrac{\omega_{pe}^2}{2\Omega_e^2} \right)$ and electron drift wave ω_{De}.

The parametric instability threshold field for the decay is following:

$$E_{th}^2 = 8\omega_0^2 B_0^2 \omega_{pe}^2 \frac{(kr_{De})^2 \nu_{ei} \gamma_{De}}{k^2 c^2 \Omega_e^3 \omega_{De}} , \qquad (2)$$

where γ_u , γ_{De} - damping of upper hybrid and drift waves respectively, $\gamma_u \cong \nu_{ei}$.

In the region above threshold $(E_0 > E_{th})$ the plasma becomes turbulent and we use the nonlinear stabilization mechanism described in [1]. Thus the differential cross section is given by "pump field" term:

$$\frac{d\Sigma_\pm}{do} \cong \left(\frac{e^2}{mc^2}\right)^2 \frac{\omega'^2(\omega' \pm \omega_{De})^2}{\omega_{pe}^4} R|\xi|^2 \frac{T_i}{T_e} n_e \left(1 + \frac{\mu^2}{8} \frac{1}{q^2 r_{De}^2} \frac{T_e}{T_i} \frac{\omega_{pe}^2 \omega_{De}}{\omega_u^2 \gamma_u \gamma_{De}}\right),$$
(3)

where $\mu = \dfrac{k_\perp E_0 c}{\omega_0 B_0} \dfrac{\Omega_e^2}{\omega_{pe}^2}$.

For typical parameters of hot plasma $n_0 = 10^{14} \text{cm}^{-3}$, Te = 10 kev, B_0 = 50 kG, the pump field differential cross section is greater then usual thermal noise term by 3 order of value.

2. We consider also the spatial echo oscillations in the relativistic electron beam (REB) plasmas due to nonlinear interaction of eigen beam oscillations (space charge waves) [4]. The expressions for echo field of second order due to nonlinear interaction of perturbations propagating parallel and perpendicular to beam one obtains. The amplitudes and forms of these echo signals are essentially different. We thus have the opportunity to diagnostic of relativistic electron beam plasmas.

3. We study the parametric interaction of three longitudinal surface waves in semi-infinite plasma of REB are investigated.

Taking wave number mismatch into account in matching conditions for waves we are shown that the parametric interaction of three eigen surface oscillations of REB will take place.

We obtain the system of equations described the time evolution of amplitudes of three surface waves E_i(i=1,2,3) taken into account the damping of waves and mismatch of wave number (the technique to derive these equations has been described in [5-7]). We shall study these equations in parametric approximation, i.e. we assume that the pump wave amplitude is constant. $E_1 = E_{10}(>>E_{2,3})$. One obtained the threshold electric field and increment of instability and estimates the parameters of REB for effective parametric interaction. The instability will take place, if the energy of waves E_2 and E_3 have the same sign. We think that these results can be useful for some free-electron laser work, as three-wave interaction processes are important in the generation of ultra-high frequency radiation.

References

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