The general theory of ionization and field instabilities in a plasma SLAB

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The problem of the development of ionization instability in an infinite plasma slab with a high electron density ne, which can be either above or below the critical one nc, supported by pump wave with frequency ω0 is considered. In contrast to [1], the angle of incidence of the pump wave is assumed to be arbitrary.

When propagation direction of pump wave, supporting discharge, is perpendicular to slab boundary, the frequencies and wavenumbers of the Stokes ω1–, *k*1– and anti-Stokes ω1+, *k*1+ waves excited in the plasma under resonance instability are close, owing to the smallness of the ionization frequency in comparison with the field frequency. Therefore, the electrons densities, for which the resonance is observed, are close and both waves are excited simultaneously. When the oblique incidence take place, due to the synchronism conditions ω1±=ω0±Ω, *k*1±=*k*0cosθ±*K*, the perturbation wavelengths for the Stokes and anti-Stokes field are different. The electron densities in the discharge, for which resonance is observed, will be also different. Therefore, in case of oblique fall in, the electron density fluctuations with frequency Ω and wavelength Λ=2π/*K*, can lead to excitation of the Stokes wave or to excitation of anti-Stokes one only.

In the approximate interaction model, the distribution of electron density and temperature over the width of the plasma slab is assumed to be homogeneous. In the absence of ionization nonlinearity, the solution of the diffusion and heat transfer equations and Maxwell's equations for electromagnetic field for isotropic plasma gives us two diffusion-heat-conduction modes describing the damping of perturbations in space and electrodynamic modes, involving surface wave (for *ne*> 2*nc*) and the leaking waves [2, 3]. When ionization nonlinearity is taken into account, the transfer of pump wave energy to the Stokes and anti-Stokes waves changes the effective coefficient of wave attenuation, and under certain conditions, leads to their amplification (convective instability).

Absolute instability in infinite system is possible by analogy with [4] in those cases where an interaction of the Stokes and anti-Stokes electromagnetic waves, or of electromagnetic wave and one of the kinetic modes (resonance instability) [1], or diffusion and heat conduction modes (strata) take place.

The proposed calculation method also makes it possible to consider the instability in plasma slab, limited in longitudinal direction, with allowance for the reflection of waves from the ends of the plasma. In this case, the range of parameters, under which absolute instability is observed, expands, since additional feedback is activated due to the backward wave, reflected from plasma boundary.

References

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