Growth and Saturation of Two-Plasmon-Decay Instability Driven by Crossing Laser Beams in OMEGA Plasmas



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Summary

The saturation of the two-plasmon-decay (TPD) instability is influenced by the ion composition of plasmas and the angular structure of laser beams

- Low-frequency density perturbations, driven by crossing laser beams, interact with primary Langmuir waves generated in the linear stage of TPD.
- In multispecies plasmas, the presence of a high-Z dopant can increase the amplitude of density perturbations.
- The onset of the Langmuir decay instability contributes to the nonlinear saturation of TPD.
- The threshold of the Langmuir decay instability can be decreased by changing the ion composition and the laser-beam optics.

In OMEGA experiments, the hard x-ray production depends on the ion composition



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The TPD instability threshold is influenced by the interplay of plasma inhomogeneity, wave damping and resonance detuning due to beam incoherence



The calculated TPD threshold is in reasonable agreement with the hard x-ray onset intensity



The interaction of incoherent laser beams with plasmas produces low-frequency perturbations in electron density



The dispersion equation for ion-acoustic waves in multispecies plasmas includes a sum of contributions from different ion species

$$\frac{k^{2}c_{s0}^{2}}{n_{e}}\sum_{i}\frac{Z_{i}^{2}n_{i}/M_{i}}{(\omega-\vec{k}\,\vec{V})^{2}+2i\gamma_{i}(\omega-\vec{k}\,\vec{V})-(5/3)\,k^{2}V_{Ti}^{2}}=1$$
Fluid
model

- \vec{V} -flow velocity; Z_i and M_i -ion charge and mass; $c_{s0}^2 = (T_e/m_p)$
- In the collisional (i–i) regime, the ion-acoustic damping is determined by the ion viscosity and ion heat conductivity.

$$\gamma_{i} = k^{2} \left(0.64 + 0.87 \frac{V_{Ti}^{2}}{c_{s}^{2}} \right) \frac{V_{Ti}^{2}}{v_{i\Sigma}}$$

where $v_{i\Sigma} = \frac{4 \ln \Lambda}{3\sqrt{\pi}} \frac{e_{i}^{2}}{T_{i}^{3/2}} \sum_{A} \left(\frac{n_{A} e_{A}^{2}}{m_{eff}^{1/2}} \right)$

* S. I. Braginskii, in *Reviews of Plasma Physics*, edited by Acad. M. A. Leontovich (Consultants Bureau, New York, 1965), Vol. 1, p. 205.

The dispersion equation for ion-acoustic waves in multispecies plasmas has several solutions

For CHSi (0.06) the solutions are:

$$(T_i/T_e) = 1$$

$$(\omega_r - \vec{k} \vec{V})^2 = 0.94 \, k^2 c_{s0}^2 \text{ and } \gamma_i \approx \gamma_H$$

$$(\omega_r - \vec{k} \vec{V})^2 = 0.43 \, k^2 c_{s0}^2 \text{ and } \gamma_i \approx 0.68 \, \gamma_C + 0.32 \, \gamma_{Si}$$

$$(\omega_r - \vec{k} \vec{V})^2 = 0.04 \, k^2 c_{s0}^2 \text{ and } \gamma_i \approx \gamma_{Si}$$

In the Zakharov model* of TPD, saturation depends on the ion-acoustic damping.

*See J. F. Myatt (JO5.00013).

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The plasma spectral density characterizes the low-frequency density perturbations driven by the ponderomotive force

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The threshold of the Langmuir Decay Instability depends on the characteristics of ion-acoustic waves



Seeding by laser-driven perturbations

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