

NONLINEAR ELECTROMAGNETIC WAVE
INTERACTIONS WITH PLASMAS

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A handwritten signature in cursive script, appearing to read 'D. Subbarao', with a long horizontal flourish extending to the right.

(D. Subbarao)

ABSTRACT

High power laser interactions with plasmas with fusion applications and similarly motivated nonlinear radiowave interactions with plasmas guided the selection of topics in the present thesis.

Self-focusing theory with an angular spectrum representation of the electromagnetic field of the beam has been formulated without restricting the generality of the dielectric constant. Detailed analysis of the paraxial and non-paraxial field structures and also the non-WKBJ modifications for a beam in a focusing medium has been presented. Normal and anomalous self-trapping have been predicted using the newly formulated paraxial theory and the Liapounoff phase-space techniques. Above threshold, a self-focusing beam has been shown to undergo oscillatory focusing till the beam-width amplitude decays to a value dictated by a self-trapping curve. Linear and nonlinear absorptions have been shown to enhance the possibility of such a beam trapping. The paraxial theories give the same results for self-trapping in non-absorbing media as the moments or variational theories for self-trapping after renormalisation of the beam-power. The latter two theories have been shown to lead to identical results for self-focusing and have also been shown to be equivalent to the reformulated paraxial theories provided focusing is very slow. Nonlinear penetration of an electromagnetic beam

into an overcritical plasma has been shown to lead to resonance absorption and profile steepening in its cross-sectional plane.

Parametric instabilities in a homogeneous and isotropic plasma have been reformulated using vector and scalar potentials of the electromagnetic and fluid velocity fields and as an initial value problem. Growth characteristics have been shown to depend on the form of the initiating perturbation.

Stimulated Raman and Brillouin scatterings in a plasma with waves propagating along or against a magnetostatic field have been shown to lead to growth and threshold resonances. The five-wave interaction which ensues when the pump is elliptically polarised has also been investigated.

Ponderomotive force and redistribution of the plasma when a magnetostatic field is azimuthal to the propagation direction of a plane and homogeneous electromagnetic wave has been investigated. It is shown that the creation of a density dip at the axis and also the generation of additional magnetic fields in the azimuthal direction can lead to wave focusing.

Debye screening modifications on ponderomotive redistribution have been investigated. Results in agreement with recent experiments on electron/ion expulsion by the ponderomotive force of a high power laser beam in a tenuous plasma have been obtained.

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