STUDIES ON PARAMETRIC INSTABILITIES IN PLASMAS

by

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DEDICATED

TO

MY PARENTS

DECLARATION

I hereby declare that the work, which is being presented in this thesis entitled, "STUDIES ON PARAMETRIC INSTABILITIES IN PLASMAS" in fulfilment of the requirements for the award of the degree of 'DOCTOR OF PHILOSOPHY', submitted in the Centre of Energy Studies, Indian Institute of Technology, Delhi, is an authentic record of the research work carried out by me under the supervision of Dr. R.P. Sharma, Assistant Professor, Centre of Energy Studies, Indian Institute of Technology, Delhi. The matter embodied in this thesis has not been submitted by me or any body else for the award of any other degree.

Yogesh Kumar Tripathi

YOGESH KUMAR TRIPATHI
(Candidate's Signature)

Certification by Supervisor:

This is to certify that the above statements made by the candidate are correct to the best of my knowledge. I feel satisfied with his work and allow him to submit his thesis.

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SUMMARY

In the present thesis, author discusses various parametric instabilities which might be important during electron cyclotron resonance heating and fast wave current drive and heating of the magnetically confined plasmas, and laser produced plasmas where the self generated magnetic field exists. Some of these investigations may be useful for explaining the excitation of low frequency modes in the ionosphere and the magnetosphere.

In the first chapter, parametric decay instability of extraordinary electromagnetic wave into an electron plasma wave and a low frequency wave (mixed mode kinetic Alfven wave or magnetosonic wave) has been studied. Applications of this investigation to tandem mirror-Upgrade (in the central cell and plug region), tokamak, laser produced plasmas and the earth's magnetosphere (at the plasma pause and beyond) have been pointed out. For example, for the typical set of parameters of the tokamak, when the kinetic Alfven wave is a low frequency wave, the convective threshold power is ~ 10 kW cm^{-2}. In addition to this, stimulated Brillouin scattering (SBS) of extra-ordinary and ordinary electromagnetic waves off ion Bernstein waves has been studied in second and third chapters. For the application point of view, the SBS of

extraordinary wave off ion Bernstein wave has been studied for TMX-U (end cell), ionospheric modification experiment, and magnetosphere (polar cusp region). The effect of pump wave angle on the homogeneous growth rate and convective threshold power has also been studied. The SBS of extra-ordinary and ordinary waves off ion Bernstein waves has been studied for an ionospheric modification experiment where extraordinary/ordinary wave was used as heater wave. The relevance of this parametric decay process of extra-ordinary/ordinary wave, to the generation of magnetic pulsation and broadband noise in magnetosphere has also been pointed out.

The author has also studied the parametric decay instability of an electron Bernstein wave into another electron Bernstein wave and an electrostatic whistler wave. The electron Bernstein wave may be a beam generated or mode converted wave. The relevance of this decay channel in space and laboratory beam plasma experiments has been pointed out. Although, Boswell and Giles have also studied the decay of electron Bernstein wave into another electron Bernstein wave and a whistler wave, but the polarization of the pump electron Bernstein wave and the decay whistler wave has not been taken as per the experiment. The author has calculated the correct coupling

coefficients in the limit of fluid model and has shown that this decay process is possible in both space and laboratory electron beam plasma experiments.

In tokamaks, fast waves are being used for current drive purposes as an alternative candidate because the prospects of lower hybrid (slow wave) current drive are bleak because of density limit. However, nonlinear effects such as parametric decay instability may occur at high power levels of fast wave being used in heating and current drive experiments. In the last chapter, parametric decay instability of fast magnetosonic wave into an electrostatic ion cyclotron wave and a mixed mode kinetic Alfven wave has been examined and application of this to tokamak plasmas is pointed out. For example, for a typical set of tokamak plasma parameters, the convective threshold power for this decay process comes out to be $\simeq 300$ W cm^{-2}.

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