

Relativistic Effects in Short Pulse Laser Plasma Interaction

by

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Submitted

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to the



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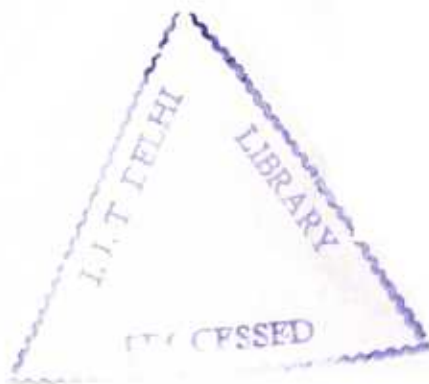
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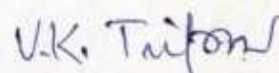
TO MY SISTER

CERTIFICATE

This is to certify that the thesis titled "RELATIVISTIC EFFECTS IN SHORT PULSE LASER PLASMA INTERACTION" being submitted by AJIT UPADHYAY is worthy of consideration for the award of the degree of DOCTOR OF PHILOSOPHY and is a record of bonafide research work carried out by him under my guidance and supervision and that the results contained in it have not been submitted in part or full to any other university or institute for award of any degree/diploma.

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May 2002.



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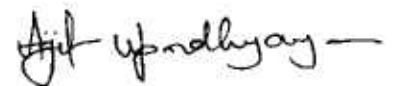
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Abstract

In the present thesis some of the relativistic effects in short-pulse laser plasma interaction have been studied.

The temporal evolution of an intense short pulse laser in under-dense plasma is analyzed. The effect of relativistic mass non-linearity on the group velocity of the laser pulse is to modify its temporal pulse shape. The distortion in pulse shape is estimated for a uniform intensity laser pulse as well as for a Gaussian intensity laser pulse.

The asymmetric self-focusing of an intense short laser pulse in a plasma has been analyzed. The laser pulse undergoes self-pulse distortion due to combined effect of non-linearity induced self-focusing and dispersion. The non-linearity arises due to relativistic mass variation. The low intensity front of the pulse converges only mildly while higher intensity portion self-focuses strongly. However, at the intensity maxima the self-focusing effect is masked by the saturation effect of non-linear refractive index. We have used source dependent expansion method to solve the paraxial wave equation with non-linear source term, retaining cross space-time derivatives of laser amplitude, thereby allowing for self-distortion of pulse.

The effect of hot electrons on the stimulated Compton scattering (SCS) of a laser in a self-sustained plasma channel is studied. The presence of drifting energetic electrons in laser produced plasma enhances the growth rate of SCS by causing stronger Landau damping of the Langmuir wave produced in the Compton process. It also weakens the guiding process as these electrons quickly

pass through the length of the channel before they could be driven out of the channel by the ponderomotive force. Thus a self-guided laser could have a large spot size at a given power. The growth rate of SCS is derived for two species plasma, non-local effects have also been included.

The second harmonic generation in a plasma channel is studied. An intense laser beam, guided through a low-density plasma channel, produces second harmonic due to ponderomotive non-linearity. The second harmonic leaks out in the high-density outer region, propagating at low angle hollow cone with respect to filament axis. The second harmonic power and its variation with channel density is estimated.

We have studied the effect of relativistic drift and thermal spread in the velocity of electron beam on the Weibel instability in the presence of a large amplitude plasma wave. The presence of a large amplitude plasma wave has a strong influence over the growth rate of Weibel instability. The enhancement in growth rate is stronger at shorter wavelengths. The growth rate of Weibel instability is obtained for electrons having high drift velocity and large thermal spread.

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