ABSTRACT

In this thesis we have studied the **DENSITY TRANSITION BASED SELF-FOCUSING OF A SHORT PULSE LASER IN PLASMA** using Wentzel-Kramers-Brillouin (WKB) and paraxial approximations through parabolic wave equation approach. In chapter-3, self-focusing of Hermite-cosh-Gaussian (HchG) laser beam in plasma under density transition has been investigated theoretically by a ponderomotive mechanism. The results obtained indicate that HchG beams give freedom to additional source parameters mode index (m) and decentered parameter (b), changing the nature of self-focusing significantly. In this chapter it is observed that strong self-focusing occurs as the HchG beam propagates deeper inside the plasma as spot size shrinks due to highly dense plasmas. Further, increase in plasma density and decentered parameter ($b \leq 1$) results in enhancement of self-focusing of laser beam in plasma.

In chapter-4, density transition based self-focusing of cosh-Gaussian laser beam in plasma with linear absorption has been studied. The effect of density ramp on the self-focusing of laser has been studied at various values of absorption levels and decentered parameter. By choosing optimized laser and plasma parameters, the combined effect of density ramp, decentered parameter (characteristic of cosh-Gaussian beam) and linear absorption on beam width parameter has been investigated. The results show that the plasma density ramp, decentered parameter and linear absorption coefficient are in such a way that they change the nature of self-focusing / defocusing of the laser beams significantly. The absorption weakens the self-focusing effect and density transition sets an early and stronger self-focusing of cosh-Gaussian laser beam in plasma.

In chapter-5, investigation of relativistic self-focusing of Hermite-cosine-Gaussian laser beam in collisionless plasma has been studied and enhancement in self-focusing is observed. Depending up on the values of optimized laser and plasma parameters, the variation of dimensionless beam width parameter as a function of normalized propagation distance has been observed. The results obtained indicate that the laser beam focuses faster and earlier with smaller spot size. The spot size can be controlled by optimizing laser plasma parameters. The decentered parameter and laser intensity has a significant role in improving self-focusing of HcosG laser beam in plasma.

In chapter-6, nonlinear propagation of Gaussian laser beam in an inhomogeneous plasma under plasma density ramp has been studied. The results reveal that the amplitude of oscillation

decreases considerably with the distance. The oscillatory behavior of beam width parameter becomes slow with increase in relative plasma density and intensity of laser beam. The saturation behavior of the beam width parameter shows that the laser beam evolves differently when propagates through underdense plasma. Further, after initial focusing of the laser beam, the relativistic mass effect is more pronounced in the region of high plasma density. Therefore, the plasma density ramp enhances the self-focusing effect to a greater extent.

In chapter-7, self-focusing/defocusing of chirped Gaussian laser beam in collisional plasma with linear absorption has been investigated. The results indicate that the laser beam is defocused due to strong diffraction and absorption effects at higher oscillation frequencies. It is further, revealed that initially the amplitude of beam width parameter is too large and continuously diverges in the collisional plasma. The chirp parameter minimizes the divergence and consequently, an earlier self-focusing of laser beam is observed. Apart from electron acceleration, the chirp can also be used to study the self-focusing / defocusing of laser beam in plasma. Thus, the chirp parameter is important for the self-focusing / defocusing of laser beam in plasma and plays a vital role in laser plasma interaction.

In chapter-8, self-focusing of a laser beam in the rippled density magnetoplasma has been studied. Effect of magnetic field and normalized ripple wave number on self-focusing of a laser beam has been analyzed at various optimized laser and plasma parameters. The results revealed that the magnetic field of a few *MG* increases the self-focusing capacity of laser beam strongly in rippled density plasma. Further, there is a strong coupling between the magnetic field and laser field. Due to the presence of suitable wavelength of density ripple in plasma, stronger and earlier self-focusing is achieved.

In chapter-9, self-focusing of Hermite-cosine-Gaussian (HcosG) laser beam in plasma under density transition has been investigated. The results obtained reveal that the density transition and decentered parameter (b) enhance the self-focusing of HcosG laser beams to a greater extent. It is noticed that the introduction of plasma density ramp makes a remarkable contribution in the process of self-focusing and it could produce ultrahigh laser irradiance over distances much greater than the Rayleigh length. Moreover, due to increase in the value of intensity of laser beam, self-focusing enhances and shifts towards lower values of normalized distance of propagation.

PREFACE

The density transition based self-focusing of a short pulse laser in plasma is studied. In this work, we apply plasma density ramp and investigate its effects on the self-focusing of laser beam in plasma. As the phenomenon of self-focusing of laser beam in a nonlinear medium like plasma is widely studied by researchers and scientists as the converged beam has a lot of energy at a focused point. In the present study a high powerful laser beam gets focused as it propagates deeper and deeper in to the plasma so that an amount of energy generated in such a process can be visualized. In many useful applications like laser driven accelerators, laser driven fusion, x-ray lasers etc., high energy is required and hence, self-focusing is very useful in these cases. We have focused our attention on enhancing the self-focusing effect by using density transition and proper selection of various laser and plasma parameters. The enhancement in self-focusing of laser beam has been observed and reported in the present study.

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Dated:

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