Stronger Self-focusing of Gaussian Laser Beam in Collisionless Plasma Based Exponential Density Profile

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Abstract. The nonlinear features of intense Gaussian laser beams traversing through collisionless plasma along with tangent upward density ramp as well as exponential density profile have been investigated theoretically in the current paper. Naturally, the ponderomotive force is primarily responsible for the collisionless plasma's nonlinear dielectric function. The differential equations for the beam width parameter (BWP) f have been constructed and numerically solved using Akhmanov's parabolic wave equation approach via paraxial and Wentzel-Kramers-Brillouin (WKB) approximations. By utilizing the fourth-order Runge–Kutta method the numerical computation is completed. The noteworthy impact of exponential density profile on propagation dynamics of a Gaussian laser beam is precisely explored and correlated with tangent upward density ramp profile. It is revealed that an exponential density ramp, rather than a tangent upward density ramp, leads the laser beams to become highly focused.

Keywords: Density ramp · Self-focusing · Plasma · Gaussian · Wentzel-Kramers-Brillouin approximation

1 Introduction

Neutral and charged particles combine to form the quasineutral gas known as plasma, which displays collective performance. Self-focusing is a fundamental, 3rd order, and fascinating nonlinear optical phenomenon in which an intense laser beam impacted on a medium modifies the optical characteristics so that the beam comes to focus within the medium. The three key mechanisms that aid to changes in the dielectric function of the plasma in the study of laser-plasma interactions: (i) collisional, (ii) ponderomotive force, and (iii) relativistic. The optical indemnity generated in solids by high-power laser beams is frequently caused by self-focusing [1, 2]. In addition to being of technological interest, the interaction of ultra-high-power laser beam with plasmas is also enriched

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