Optimizing laser focal spot size using self-focusing in a cone-guided fast-ignition ICF target

Oriza Kamboj[1], Harjit Singh Ghotra[2], Vishal Thakur[1], John Pasley[3] and Niti Kant[1]
[1] Department of Physics, Lovely Professional University, [2]Extreme Light Infrastructure-Nuclear Physics (ELI-NP), "Horia Hulubei" National Institute of Physics and Nuclear Engineering, [3]York Plasma Institute, Department of Physics, University of York
e-mail (speaker): kambojoriza1964@gmail.com

Here we present the findings of a recently published study [1] which considers a scheme for strong self-focusing of a laser beam interacting with a cone-guided fast-ignition inertial confinement fusion target. Cone pre-plasma filling is employed as the optical medium for reducing the laser beam waist. The objective of this work is to reduce the focal spot size at the interior of the tip of the re-entrant cone to that required for efficient coupling to the dense imploded fuel core. This is challenging to achieve in a large laser system using the standard optical components of a chirped-pulse-amplified (CPA) laser-beam chain where the spot sizes produced are often significantly larger than would be desirable for fast ignition. Cone pre-plasma filling is anyway difficult to avoid entirely when illuminating a cone with a high-energy CPA laser system due to the challenges of reducing laser pre-pulse to below the threshold for plasma production. For deriving the differential equation which governs the progress of the laser beam-width with propagation distance, paraxial theory in a WKB approximation has been used. A simulation is performed assuming strong self-focusing in accordance with the laser parameters and plasma density profile chosen. The scheme described reduces the defocusing of the laser beam. Hence, the laser beam remains focused to a small spot size over several Rayleigh lengths, as shown in figure 1.

Reference

[1] Optimizing laser focal spot size using self-focusing in a cone-guided fast-ignition ICF target, O. Kamboj, H.S. Ghotra, V. Thakur, J. Pasley and N. Kant, The European Physical Journal Plus, 136(5), pp.1-11, (2021).

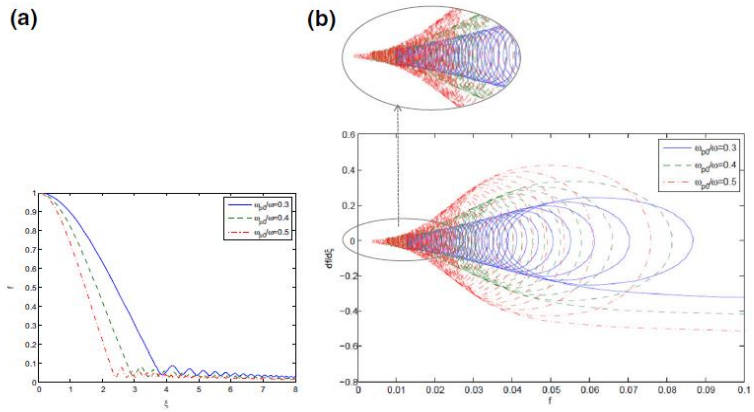

Figure 1: In this figure (a) Variation of beam width parameter with normalized propagation distance and (b) Phase space plot for self-focused Gaussian laser beam, for different values of ω_{p0}/ω = 0.3, 0.4 and 0.5 at ω_{r0}/c = 40 and d=8.