Seminar

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Institute for Plasma Research

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Title: Intense laser interaction with an inhomogeneous plasma: Validation of electromagnetic fields at oblique incidence and different polarization

Speaker: Dr. Mamta
Institute for Plasma Research, Gandhinagar

Date: 11th February 2025 (Tuesday)

Time: 10:30 AM

Venue: Seminar Hall

Abstract

The interaction of high-contrast, intense femtosecond laser pulses (>10^{16} W/cm^2) with solid-density targets often generates an inhomogeneous plasma layer at the target surface. This inhomogeneous plasma-density gradient, encompassing both under-dense and over-dense regions, plays a critical role in laser absorption through resonance, laser-driven fusion, and particle acceleration processes. Understanding the spatial and temporal dynamics of the electric and magnetic fields in these scenarios is particularly challenging, especially for obliquely incident laser pulses with varying polarization (p, s, or circular) at relativistic intensities. Analytical solutions for such systems are typically limited only in some simplified cases. In this study, we analyze the electric and magnetic field profiles produced by differently polarized incident laser pulses (modeled as plane waves) interacting with an inhomogeneous plasma characterized by a linear density gradient. Our approach combines analytical methods [1-3] with numerical simulations using the 1D-3V particle-in-cell (PIC) code LPIC++ [4]. We demonstrate that at lower laser intensities (<10^{17} W/cm^2) the self-consistent PIC simulation results align closely with analytical predictions for various polarizations and incidence angles, including resonance conditions. However, at higher intensities (>10^{17} W/cm^2), deviations arise due to the breakdown of analytical assumptions, with the PIC simulations providing more accurate results. This study highlights the importance of PIC simulations in exploring the unexplored regime of relativistic laser intensities and plasma density inhomogeneities, which are frequently encountered in laser-solid interactions.

Reference:

1 W. L. Kruer, The Physics of Laser Plasma Interactions, (Redwood City, CA: Addison Wesley, 1988).
2 H. M. Milchberg and R. R. Freeman, J. Opt. Soc. Am. B **6**, 1351-1355 (1989).
3 B. Li, Q. Nie, X. Wang, Z. Wang, A. Mao and P. Chen, AIP Advances 9, 095020 (2019).
4 R. E. W. Pfund, R. Lichters, and J. Meyer-ter-Vehn, LPIC++ a parallel one-dimensionalelectromagnetic particle-in-cell code for simulation of laser–plasma-interaction," in Super Strong relativistic electromagnetic particle-in-cell code for simulation of laser–plasma-interaction," in Super Strong Field in Plasmas, edited by M. Lontano et al., AIP Conf. Proc. Vol. 426 (American Institute of Physics, Melville, New York, 1998), p. 141.