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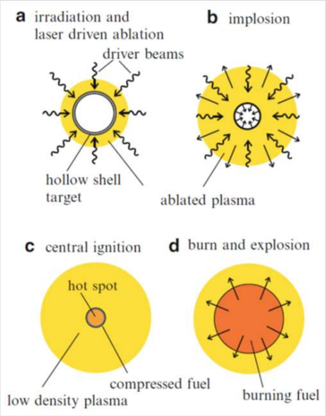
2026, March 4 – 14:00, Room A207 – Polo Ferrari 1

New challenges in Laser-Plasma Interaction research for Inertial Fusion Energy

Abstract



Inertial Fusion Energy (IFE) relies on repetitive and energy efficient compression, ignition and burn of a millimetre sized spherical pellet containing the fuel. In the original Direct-Drive (DD) scheme of Inertial Confinement Fusion (ICF) the laser beams imping directly on the pellet and drive the implosion, delivering their energy to the plasma at densities below the critical density. In the Indirect-Drive (ID) scheme laser beams imping on the inner walls of the Hohlraum surrounding the pellet, generating X-rays that drive the implosion. In both schemes, inelastic scattering of the laser light with density fluctuations can excite electron or ion acoustic plasma waves, driving the growth of the so-called laser-plasma instabilities (LPI), which can have a dramatic impact on the implosion performance and therefore are a great concern for ICF. Among LPI, Stimulated Brillouin Scattering (SBS) and Stimulated Raman Scattering (SRS) lead to a net loss of laser energy therefore increasing the driver energy requirements. Cross-Beam Energy Transfer (CBET) can produce an imbalance of laser beam coupling and therefore prevent the compression efficiency. Finally, SRS and Two Plasmon Decay (TPD), can result in the generation of hot electrons, that can be absorbed by the cold fuel, enhancing its entropy and preventing ignition.

In the past 40 years, major effort was dedicated to the theoretical and experimental investigation of these processes, and to identify the proper ways to control or mitigate their effects on the implosion performance, finally leading to the recent successful ignition demonstration at the National Ignition Facility using the ID scheme. New investigations are however needed for interaction conditions typical of the DD scheme, which is more suitable for energy production and for a future reactor. Even more important is the investigation of LPI in advanced ignition schemes like the Shock Ignition scheme, where the laser intensity is an order of magnitude higher than in the classical DD scheme.

In the first part of the seminar we will give an overview of ICF schemes and LPI mechanisms. In the second part we will discuss the new challenges for LPI investigation and the recent technology advancements for the mitigation of their effects, showing also recent experimental results obtained in campaigns at Gekko XII, PALS, VULCAN and ELI laser facilities, carried out in the framework of the EuroFusion research program.

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