Fusion energy research with high power lasers in Europe: the HiPER+ programme

*Leonida A. Gizzi**

Istituto Nazionale di Ottica (CNR-INO), Pisa, Italy
Extreme Light Infrastructure ERIC, Dolní Břežany, Czech Republic

e-mail: la.gizzi@ino.cnr.it

High-power laser driven inertial fusion energy (IFE) is entering a pivotal phase in Europe, building upon the HiPER+ flagship initiative. Coordinated experimental access to existing national and international facilities supports laser development and the study of laser–plasma interactions and high-energy-density (HED) physics for direct-drive implosions, providing a platform for advancing Inertial Confinement Fusion research. These initiatives mark a decisive step toward establishing a European framework for IFE, complementing magnetic confinement approaches and reinforcing Europe's scientific role in the global fusion landscape. Ultimately, the goal of HiPER+ is to provide the foundation for a next-generation European laser fusion facility capable of demonstrating ignition and high-gain conditions, reinforcing Europe's leadership in inertial fusion energy and its contribution to a sustainable, carbon-free energy future.

In the presentation I will review the key physics challenges that remain for achieving efficient coupling of laser energy to the target, for mitigating hydrodynamic and parametric instabilities (e.g., Rayleigh-Taylor, laser imprint, Brillouin and Raman scattering), and for optimising energy transport in warm dense matter. HiPER+ focuses on these issues through integrated design and simulations and experimental campaigns across major laser facilities such as ELI, PHELIX, LULI, PALS and smaller scale national laboratories for target and diagnostic development, as well as for training. I will discuss about parallel efforts tackling technologies—high-efficiency diode-pumped lasers, precision target fabrication and injection, radiation-hard diagnostics, and materials for extreme environments. This coordinated effort bridges fundamental plasma physics and engineering design, establishing a clear pathway from laboratory-scale ignition experiments to reactor-relevant operation.

* On behalf of the HiPER+ collaboration