‘Position Paper’

Laserlab-Europe AISBL Expert Group in Inertial Confinement Fusion / Inertial Fusion Energy (ICF/IFE)

The concept of laser-driven inertial confinement thermonuclear fusion (ICF) for energy production [1] was originally proposed in 1972 in seminal papers by Nuckolls and Basov [2, 3] that initiated a worldwide effort to demonstrate inertial fusion ignition in the laboratory. After five decades of continuous progress toward ignition, in August 2021 the NIF at LLNL, USA, announced a major advance, with 72% of the 1.9 MJ input laser energy converted into products of the D-T fusion reactions, namely neutrons and alpha particles [4]. The record 1.35 MJ of output fusion energy was eight times higher than the yield previously obtained and at least 100 times bigger than results obtained about 10 years ago in the framework of the so-called National Ignition Campaign done at NIF between 2009 and 2012. With this result the ignition milestone, that requires the fusion energy yield to be equal to the input laser energy, is only a small step away, proving unambiguously the validity and the feasibility of the ICF concept.

In 2006, the HiPER (High Power Energy Research) was included in the roadmap of European Strategic Forum for Research Infrastructures (ESFRI). The project aimed at exploring the science and technology of high-gain laser-driven fusion schemes, with a special focus on shock ignition direct-drive approach. Another equally important objective of HiPER was to build a sustainable, long-term, basic science programme in a wide range of associated fields and applications. Now the mega-Joule scale energy yield demonstrated at the NIF confirms that laser-driven ICF is a viable solution for fusion energy. The European scientific community is strongly advocating [5,6] the establishment of HiPER+, a new programme in Europe aimed at pursuing the original HiPER objectives and developing a roadmap to assess the feasibility of an IFE power plant based on burning of deuterium and tritium.

With the current international activities and renewed interest in ICF as a viable option for fusion energy production it is extremely timely therefore for a Laserlab-Europe AISBL Expert Group to develop a broad network of researchers across Europe, to promote and focus the activities of each institution to define mutual collaborations and prepare joint experimental campaigns. There are currently 13 Laserlab-Europe AISBL Member institutes participating in the Expert Group (CELIA, CESTA, CLF, CLPU, ENEA, GSI, IPPLM, IST, LULI, Orion, PALS, STRATH & Wigner) with many other groups already involved.

Aims and Activities of the Expert Group:

The aims of the Expert Group are to strengthen the collaboration between research groups in Europe in ICF/IFE and to discuss potential future advances relevant to ICF. The activities for the Expert Group have been broken down in to six main categories which will initiate focussed discussions:

- European IFE Roadmap

  - Develop European roadmap for IFE.
  - Develop strategy and lobby for a medium scale European IFE demonstrator facility.

- Advanced Direct Drive schemes

  - Further develop advanced Direct Drive schemes for ICF.
  - Modelling of Direct Drive schemes.

- Laser technologies for IFE platforms

  - Working on high repetition rate laser technologies: including efficient diode pumping, high repetition rate and broad-band wavelength capabilities.
  - Laser beamline modelling for optimum performance.

- Related technology development (targets, diagnostics etc)

  - Development of target technologies relevant to IFE (with strong synergies with the Laserlab-Europe Expert Group on Micro- and nano-structured materials for experiments with high-power lasers).
  - Improving PW kJ-class diagnostic laser capabilities (ARC, PETAL, etc.) for ICF research (with strong synergies with the Laserlab-Europe Expert Group on Laser-generated EMP).

- Experiments on existing platforms

  - Identify key experiments on current intermediate & large scale international facilities to progress understanding of ICF/IFE.
  - Coordinate the generation of collaborative proposals for accessing facilities.

- IFE reactor issues (overlap with Tokamak technologies)

  - Investigate reactor relevant issues.
  - Study of IFE materials considerations.

Activities:

The following are Expert Group initiatives for networking:

- Organise regular seminars open to the community
- Hold workshops relevant to the different activities, both in person and on-line
- Offer training opportunities relevant to IFE
- Researcher exchange
- Develop ICF/IFE publication database

References:

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[4] A.L. Kritcher et al., 'Design of inertial fusion implosions reaching the burning plasma regime.' *Nat. Phys.* (2022) https://doi.org/10.1038/s41567-021-01485-9
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[6] S. Atzeni et al., 'Breakthrough at the NIF Paves the way to Inertial Fusion Energy.' EuroPhysics News 53/1 (2022) https://www.europhysicsnews.org/articles/epn/pdf/2022/01/epn2022531p18.pdf