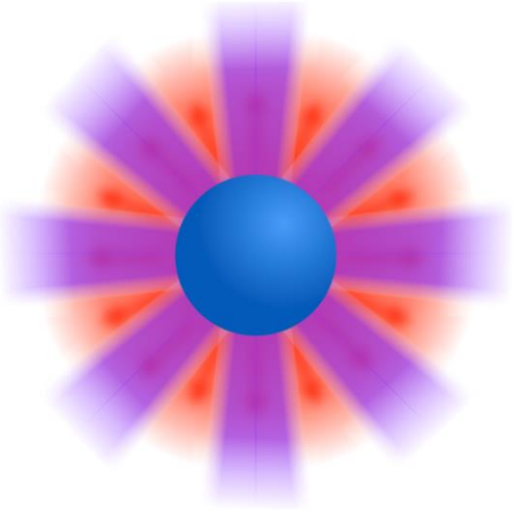
# Laserlab-Europe AISBL Expert Group in Inertial Confinement Fusion (ICF/IFE)

**The recent achievement at the National Ignition Facility (NIF) in the USA of nearly reaching fusion ignition [1] with laser-driven technologies sets a historical milestone in fusion energy research. It makes inertial fusion a viable approach for future energy production. Europe has a unique opportunity to empower research in this field and the scientific community is prepared to engage in this journey. A Laserlab-Europe AISBL Expert Group in ICF/IFE has been established as a forum for discussing potential advances in the field within Europe.**



**Background:**

The concept of laser-driven inertial confinement thermonuclear fusion (ICF) for energy production was described 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 71% of the 1.9 MJ input laser energy converted into products of the D-T fusion reactions, namely neutrons and alpha particles. 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, demonstrating the validity, and indicating the potential 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. HiPER allowed for the first time to tackle not only target ignition and burning but also reactor relevant issues like chamber design and materials under IFE (Inertial Fusion Energy) conditions. 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 [4,5] 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.

Some important steps and scientific milestones that give confidence in the next stages to demonstrate high gain, direct drive fusion ignition have been done and will be done within the framework of the enabling research programme of EUROFusion. There is currently a Project CfP-FSD-AWP21-ENR-01 looking specifically at “Advancing shock ignition for direct-drive inertial fusion” 2021-2024 by a consortium of European researchers. However, it is clear that now we need a clear big step forward, which is the reason of the HIPER+ proposal.

**Expert Working Group objectives:**

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, STATH & Wigner) with several other groups already showing a keen interest in being involved (see list below).

The aims of the Expert Group are to discuss potential future advances relevant to ICF including, but not limited to:

- strengthening the collaboration between research groups in Europe in ICF/IFE;
- developing ideas for advanced direct drive schemes for ICF;
- development of target technologies (with strong synergies to the Expert Working 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;
- working on high repetition rate laser technologies: including efficient diode pumping, high repetition rate and broad-band wavelength capabilities;
- orgainse experiments on intermediate scale facilities;
- study IFE materials considerations;
- investigate reactor relevant issues.

**Activities:**

The following are planned initiatives for networking:

- Establish and develop website for the Expert Group Laser-driven Inertial Confinement Fusion (ICF) — LASERLAB-EUROPE
- Develop Work Packages to focus Group activities
- Collate publications from the group
- Organise regular seminars open to the community
- Hold workshops relevant to the different activities, both in person and on-line

**Relation to EC missions:**

The topic of the Expert Group is mainly related to the EC-Horizon mission area “Climate-neutral and smart cities” and the EC Green Deal. It addresses thematic areas of the research that will be strategically directed by the EC in the present and immediate future including clean energy production, which can be achieved with the realization of plants based on Inertial Confinement Fusion.

**References**

[1] 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

[2] N.G. Basov, O.N. Krokhin and G.V. Sklizkov, ‘Heating of laser plasmas for thermonuclear fusion.’ In Laser Interaction and Related Plasma Phenomena vol 2 (New York: Springer) p.389 (1972)

[3] J. Nuckolls et al., ‘Laser Compression of Matter to Super-High Densities: Thermonuclear (CTR) Applications.’ Nature 239, 139–142 (1972) https://doi.org/10.1038/239139a0

[4] S. Atzeni et al., ‘An evaluation of sustainability and societal impact of high power laser and fusion technologies: a case for a new European research infrastructure.’ *High Power Laser Science and Engineering, 9*, e52 (2021) https://doi.org/10.1017/hpl.2021.41

[5] 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

**Initial membership of the expert group:**

**Laserlab-Europe AISBL Members:**

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**Initial non-member participants:**

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