The continuation of HiPER- HiPER Plus

Proposal for a new "direct-drive" laser-fusion programme in the EU

Dear colleagues,

With this letter, we wish to prompt the European laser-fusion community to rejuvenate the enthusiasm that spawned the pioneering "HiPER" project, and work together to set the building blocks of a new related EU project. Our initiative is timely because of the very encouraging results obtained at the NIF facility in the US, where a recent laser fusion experiment nearly reached the ignition threshold.

In detail:

The HiPER (High Power Energy Research) project included in the 2006 European "ESFRI" Roadmap, aimed to explore the science and technology of laser-driven fusion schemes, as well as to develop a roadmap to assess the feasibility of commercial power production based on laser-driven fusion of deuterium and tritium. Another equally important objective of HiPER was to build a substantial, long-term, basic science programme in a wide range of associated fields and applications.

Coordinated by the STFC in the UK, the Preparatory Phase of HiPER commenced in April 2008 and concluded in April 2013 with the publication of an extensive Final Report (http://www.hiper-laser.org). The European Commission co-funded the project and was in charge of the project's management, coordination and governance. The research and technical developments were further funded jointly by STFC and the Ministry for Education Youth and Sports of the Czech Republic. Other partners offered extremely valuable "contributions in kind", comprising, among others, laser beam time at national research infrastructures in France, Czech Republic and the UK, and computational resources in Italy, Spain, Greece and Portugal. National networks for HiPER were set up and funded by national governments. In some cases, as for instance in Greece, Italy and Portugal, peripheral facilities were established in order to conduct HiPER physics and technology related research.

During the Preparatory Phase of the project, scientists worked on a plan to investigate the physics of several direct-drive fusion schemes mainly "fast ignition" and "shock ignition". Shock ignition has the advantage of being amenable to proof-of-principle experiments using the Laser MégaJoule (LMJ) facility in France once all beams are activated. The Preparatory Phase also gave the opportunity to tackle crucial laser-related development issues, including repetition rate, bandwidth, smoothing, transport and focusing, materials and science-based technologies for reactor required for future power production. Incidentally, these topics are now actively investigated in laser-driven plasma acceleration, another notable application of high-power lasers that has been growing rapidly at a large-facility level and has recently been included in the ESFRI roadmap.

This project led to hundreds of peer-reviewed publications covering a large variety of topics related to laser-driven fusion physics and technology, as well as to the basic science programme of HiPER. It also resulted in many high-profile invited lectures at international conferences in Europe, the U.S., Japan, Canada, China and Russia, but also events such as exhibitions and visits to companies aiming to encourage industrial participation in future phases. Moreover, public lectures and visits to schools and universities were organised to raise public awareness on fusion energy challenges.

Yet, the most important output of the HiPER project so far is probably its impact on the laser-fusion community, which has experienced an impressive growth in Europe, mainly directed towards the exploitation of laser fusion for future energy production. This expansion has also been driven by a dedicated physics training and networking programme via specially realised actions, which are still ongoing (Erasmus IP's, COST actions, Erasmus+ actions, etc.). This enlarged scientific community constitutes an important legacy for future laser fusion activities in Europe and also worldwide. Many highly trained European scientists have manned laser-fusion-related facilities in the US, Japan, and lately in China.

At the 2018 ECLIM conference (22-26 October 2018), organised by IPPL in Rethymno, Crete, a discussion was initiated during a dedicated meeting on how to restart HiPER as a fusion physics, technology and basic science programme based on the legacy of its Preparatory Phase. All participants agreed that the community gathered around the preliminary HiPER project should continue collaborating, but also that a revamped ambitious research programme would be very valuable.

Since the end of the Preparatory Phase of HiPER in 2013, research on laser-driven fusion physics and technology survived through funding obtained from the EUROFUSION Enabling Research projects, the IAEA networking activities, the COST actions, the Erasmus+ networking actions and other sources. But this is not enough. As laser fusion science and technology are continuously improving worldwide, it is now the time to launch a new coordinated European project. HiPER stands as a well-recognised brand name, but which needs refreshment, new actions and enthusiasm to revive its credibility. Collaboration of the "reactivated" HiPER research programme with existing laser fusion related projects is important until its own funding becomes available. Furthermore, the cooperation with the magnetic fusion community will address common challenges spanning fusion materials, diagnostics and energy transport.

In light of the above, and encouraged by the rapid and impressive progress of our US colleagues at the NIF and Omega facilities, we propose a step-by-step reactivation of the HiPER project:

Step 1: Convene a scientific committee to discuss the global scope of the project and prepare a Declaration of Interest.
Step 2: Prepare a HiPER-Plus reactivation collaboration agreement for circulation in the community.
Step 3: Develop a research roadmap to investigate the physics of laser-driven fusion schemes in order to restart HiPER-Plus on solid, long-term grounds. HiPER-Plus will be a High Energy Density (HED) Science programme dedicated to the physics and technology of laser fusion ignition, the physics of fusion materials and advanced technologies for high-repetition-rate, high-average-power broadband lasers.
Step 4: Communicate the laser-driven fusion physics and basic science roadmap to public bodies and private enterprises, to national governments as well as to Brussels, with the goal of promoting a solid and diversified background for funding opportunities. The final objective is to reinstate the HiPER-Plus project on the ESFRI roadmap, a required step to construct a European intermediate-energy facility dedicated to laser fusion.

There are strong reasons to reactivate the project. The need for new energy sources that are both sustainable and free of CO_2 emission is becoming urgent and vital for humankind. From a physics point of view, although the indirect-drive approach investigated at NIF and other large-scale laser facilities has made huge advances in recent years, it seems ill-suited to reaching the large energy gains that future fusion reactors will require. For this goal, direct drive, including among others shock ignition, appears a more viable approach, and can today be successfully studied at several laser facilities in Europe (PALS, Phelix, LULI2000). Integrated experiments can be performed at the Omega facility in the US (on a collaborative basis or through funding provided by the HiPER-Plus project). Full-scale demonstration experiments will be possible at LMJ, which in the next few years will get a sufficient number of beams to achieve uniform target illumination. Finally, the L4 laser system at the ELI-beamlines facility in Prague will soon, and for the first time, couple high-energy (~ kJ) pulses operating at high shot rate (of the order of 1 min). Besides allowing many more HED experiments to be performed, this new facility will make it possible to examine the needs and challenges of future high-repetition-rate, fusion-related experiments. In addition, the need to follow HiPER previous assessments of science-based technologies in materials, first wall and blanket design for advance reactors is strongly experimentally-computationally needed in complementary action, when possible, with magnetic confinement teams.

In conclusion, the restart of HiPER-Plus as a science-based project is both important and timely as it will provide a strong scientific basis for the development of a laser fusion facility in Europe and help unify the efforts of a very active scientific community, creating the foundations required for the future generation of clean, sustainable energy for humankind via Inertial Fusion Energy.

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The initiative and the letter have been approved by the BP&IF section of EPS.