EuCARD-2

Enhanced European Coordination for Accelerator Research & Development

Press article

Laser plasma accelerators

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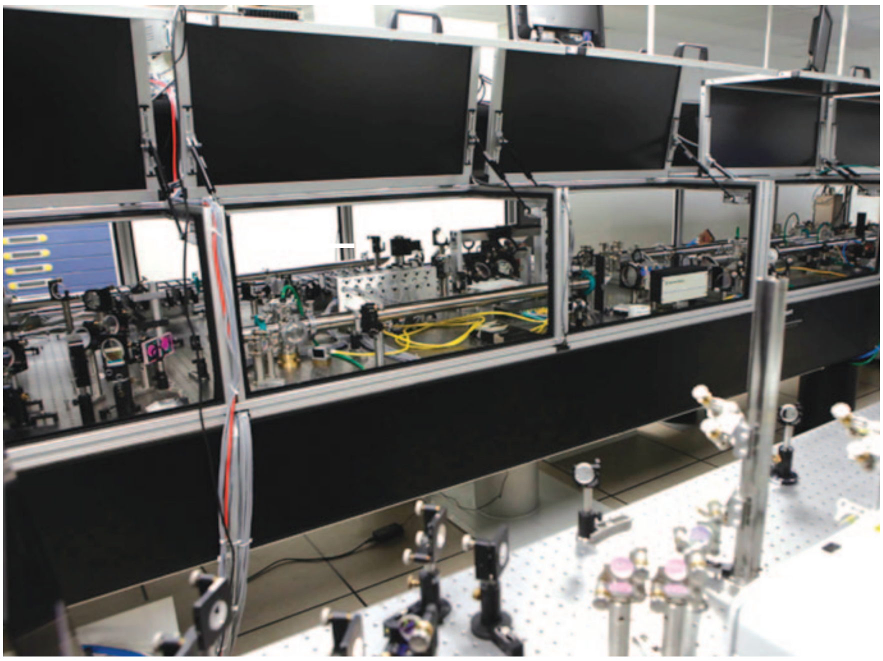
Victor Malka sets out Europe's efforts in laser plasma acceleration, the support the EU and ERC is providing and the importance of now developing laser plasma accelerators

Laser plasma accelerators

During the past few years, plasma medium have attracted increasing interest because of their ability to sustain extremely strong electric fields. Mastering the motion of charged particles in accelerating fields has allowed physicists to make significant breakthroughs. Optimising the interaction between intense laser and the plasmas, high quality and energetic particle beams are now produced in a compact and reliable way.

Across the world, this field of research has grown alongside the impressive increase of high power laser facilities that are now commercially available. In Germany, for example, about seven facilities provide PW-class lasers for covering the many aspects of laser plasma interaction. In France, an even more audacious project at the Institut de la Lumière Extrême, named the Apollon 10 PW laser system, is planned to deliver peak power of 10 PW.

In parallel to the development of powerful laser systems that are required to reach higher and higher particle energies, the research activities that are conducted with smaller lasers working at a higher repetition rate need to be better supported. They are crucial for not only basic science but also for the many societal applications. Many of the scientific breakthroughs obtained in this domain have been mainly with small laser systems, for example at Laboratoire d'Optique Appliquée, with a few tens of TW laser power, we have demonstrated different schemes of injection that allow us to produce high quality particle beams and explore their potential for application.



Partial view of the 30 TW laser system of the 'salle jaune' at the Laboratoire d'Optique Appliquée

To be competitive with other existing and commercial accelerators, we have to balance our support of research associated with the development of more compact laser systems, working at higher repetition rates, with a moderate cost. Conventional accelerators that are commercially available are extremely robust, efficient and compact. They can provide a high quality particle beam with very high average currents, which is not the case of laser plasma accelerators today. For each application, one therefore has to clearly evaluate the pertinence of this new approach, and this has to be done in a rigorous way in order to avoid any overselling which could weaken the laser community.

European efforts and strategy

Europe has invested significant funding through the three Extreme Light Infrastructures (ELI), are under construction in the Czech Republic, Romania and Hungary, in order to procure some of the world's most advanced powerful laser systems from international suppliers. The construction activities in the Czech Republic and Romania each have a €50m budget. In Hungary, the ELI-ALPS project will soon begin construction, and important steps for laser development will be made. On the technological side, two major contracts have been signed with talhès Optronique for the supply of ELI-NP's high power laser system (2x10 PW) in Romania and with Lawrence Livermore National Security (LLNS) for the supply of ELI Beamlines' L3 laser (10Hz, ultra-short pulse, multi-PW diode-pumped laser) in the Czech Republic.

The ELI Delivery Consortium International Association (AISBL) has been established to support and co-ordinate the implementation of the three ELI pillars, as well as to ensure that ELI is a unified, pan-European infrastructure. With this association, the ELI-ERIC Consortium will be created, which will govern, operate and finance ELI after 2017.

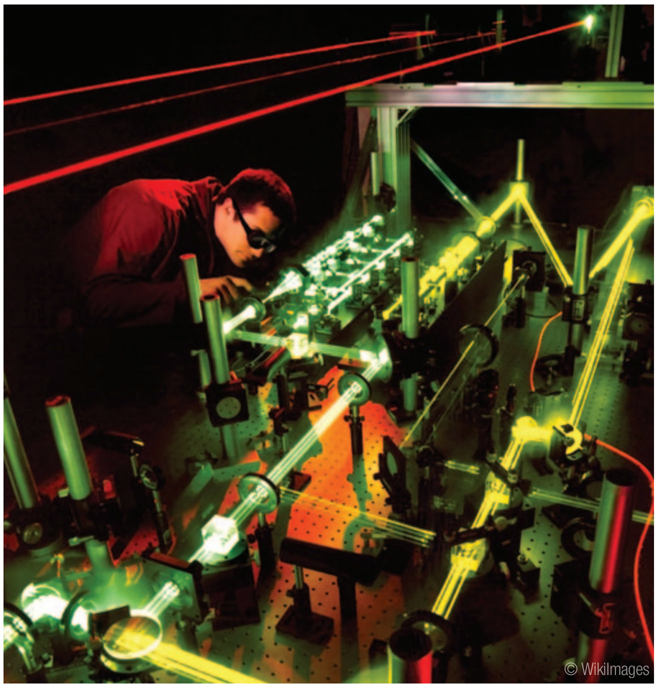
The ELI's scientific programme covers nuclear physics, attosecond physics, laser plasma interaction, plasma acceleration and high field science; it aims to generate bright particle beams and bright radiation beams. The broad range of parameters of these sources, from an attosecond to a few femtoseconds, will open the route for exploring the study of ultra fast phenomena. The ultra-high peak current of the electron beam will open a chance to build a compact free-electron laser (FEL) machine. Medical applications for cancer imaging and treatment will also be a major development at these facilities.

The high field regime that will be reached with these laser will also open up new studies relating to non-linear quantum electrodynamics, which is stimulating the theoretical community. Interacting with an energetic electron beam with an extremely low energy spread intense laser will produce a unique gamma ray beam of interest to nuclear physics. This partial list of objectives indicates the many benefits to society, including medicine, biology, security and chemistry; this also includes many benefits for basic science in domains such as atomic physics, material sciences, accelerators and astrophysics, with both theoretical, numerical and experiment challenges.

EU funding

ELI is the fruit of continuous efforts that have been pursued in Europe by national laboratories with strong support from the EU. Since 2003, the Union has invested millions of euros in collaborative research programmes through LASERLAB, CARE and EUCARD (1 and 2). This support has helped to structure the European scientific community, develop collaborative experiments and establish a strong networking activity. Importantly, this effort has allowed young trained researchers and students to join programmes from countries where infrastructures do not exist.

The European Research Council has also started funding many new grants in the field of laser-related science, which has helped encourage many high-level researchers to stay in Europe and explore new risky approaches; this also boost the careers of young researchers who have proposed new approaches. The four ERC grants allocated to the development of unconventional approaches to accelerating particles, such as the laser plasma accelerator



approach, demonstrate the importance of this topic. EU support is also particularly important due to the extremely high level of the international competition. In Asia and the Americas, around 30 facilities have been developed over the last ten years, and more facilities are under construction, making competition even more severe.

Due to the maturity of this field, it is time now to move from laser plasma acceleration to laser plasma accelerators. To do so, we are setting up a design study project that in four years will enable the building of a reliable laser plasma accelerator that can work 90% of the time, with FEL as a pilot application.

Among the many aspects of this project, one major priority will be in resolving all the technological aspects required in engineering developments that are not sufficiently funded in academic laboratories but are crucial to reaching the challenging objective of being relevant to Horizon 2020. The results of this design study will allow the creation of a unique laser plasma accelerator for FEL, as well as host users from many different fields.

Importantly, different issues will be addressed to master all the technological challenges evaluate of the pertinence of laser plasma accelerators for the purpose of high-energy physics. This will lead to the possibility of using this approach with other schemes that use a particle beam (electron or proton) as a driver in the plasma or dielectric medium.

HORIZON **2020**

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