# Master 2: *International Centre for Fundamental Physics*

## ***INTERNSHIP PROPOSAL***

Laboratory name: Laboratoire d'Optique Appliquée (Institut Polytechnique de Paris)
CNRS identification code: 7639
Internship director'surname: Sébastien Corde, Professor at Ecole Polytechnique
e-mail: sebastien.corde@polytechnique.edu Phone number: 0169319710
Web page: http://loa.ensta-paristech.fr/
Internship location: 181 chemin de la hunière, 91120 Palaiseau

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: IP Paris graduate school application

### Particle acceleration in the relativistic interaction of laser, particles and plasmas

Nowadays, particle accelerators based on radio-frequency (RF) technology are being used in a very broad range of applications, from free-electron lasers or medicine to particle colliders for high-energy physics. The electric field of these accelerators is however limited to 100 MV/m because of the breakdown of the metallic RF cavity that contains the electromagnetic field. As we push the frontier of particle physics to higher particle energies, conventional RF accelerator techniques are attaining their limit, and the prospect for next-generation machines, beyond the Large Hadron Collider (LHC) at CERN, is hindered by the prohibitive size and cost of such machines. New concepts are therefore emerging to circumvent this barrier. The use of an ionized gas –or plasma– is one such concept, where the already broken-down medium can sustain electric fields that are several orders of magnitude larger than the RF limit. These plasma accelerators are holding out the promise of more compact and more affordable particle accelerators. They are increasingly considered as a mean to push the energy frontier of particle physics even higher.

Two different strategies are being studied in the research field of plasma accelerators. They differ in the way the electric fields are established in the plasma. In the first one, a short-pulse and intense laser is used to excite a space- charge disturbance wave in his wake as it travels through the plasma. Very large electric fields are associated to this plasma wave, in which electrons can be accelerated with large energy gradients. This method has strongly benefited from the advent of laser systems delivering on-target intensities greater than $10^{18}$ $W.cm^{-2}$. This laser-driven strategy is referred to as the Laser WakeField Accelerator (LWFA). The second strategy uses instead a particle beam (typically made of electrons) to excite the plasma wave, and relies on the beam-plasma interaction. This beam- driven method is referred to as the Plasma WakeField Accelerator (PWFA).

The internship and the PhD will be at the interface between these two fields of research, involving both the relativistic interaction between laser pulses and plasmas and between particle beams and plasmas. By taking advantage of the specific properties of these interactions, the goal is to demonstrate that one can produce and accelerate new types of particle beams with unprecedented quality, and as a result enable new radiation sources of X-rays and gamma-rays.

During the internship, the student will work on an experiment using the high-power laser system of LOA, where new injection techniques in PWFAs powered by laser-accelerated electron beams will be explored. The work will include the preparation of the experiment, the experimental run with laser beam time of Salle Jaune, and the data analysis of the experimental results. The PhD project will aim at addressing some key challenges in the field of plasma acceleration, in particular the preservation of the excellent beam quality required for high-energy colliders, as well as showing that these plasma accelerators can work with high energy efficiency.

| | |
|---|---|
| Condensed Matter Physics: YES | Soft Matter and Biological Physics: YES |
| Quantum Physics: YES | Theoretical Physics: YES |