PHD AND INTERNSHIP PROPOSAL

Institutions: Ecole Polytechnique, Stanford University

Laboratories: Laboratoire d'Optique Appliquée, SLAC National Accelerator Laboratory

Lab addresses: 181 Chemin de la Hunière, 91120 Palaiseau, France

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PhD conditions: **The PhD can be funded by the laboratory and the salary will account for the higher living costs of Paris area and San Francisco bay area.**

Title: Ultrabright beams in plasma-based particle accelerators

To unlock the mysteries of the subatomic world and to study matter's fundamental components and the forces between them, physicists use particle colliders to smash highly energetic particle beams into one another. But as we push the particle energy of these colliders even higher, conventional accelerator techniques are attaining their limits and new concepts are emerging. The use of an ionized gas —or plasma— circumvents the most significant barrier of conventional techniques by increasing the energy gained per unit length by several orders of magnitude. Plasma-based particle accelerators therefore hold 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.

One strategy being studied in the research field of plasma accelerators consists in using a particle beam (typically made of electrons or positrons), « the driver », to excite a high-amplitude plasma wave [1], that can then be used to accelerate the main particle beam [2]. While beam-driven plasma accelerators have made considerable progress in the past decade to accelerate beams of electrons and positrons [1-4], a new area of research is emerging and is focusing on the brightness of the accelerated beams, which quantifies the particle density in phase space and characterizes the quality of the beam. This very challenging topic is of crucial importance for the future of the field and could be a game changer. The aim of the PhD will be to address two important related questions: (i) how plasma-based particle accelerators can preserve the quality and brightness of a beam as it is coupled into the accelerator and as it is accelerated to high energies, and (ii) how to leverage plasmas to generate new beams of unprecedented brightness.

The PhD thesis will be conducted under joint supervision between Ecole Polytechnique in France (LOA) and Stanford University in the US (SLAC), and the PhD student is expected to share his time between the two laboratories. This joint-supervision PhD will give the opportunity of an early international research experience in two internationally renowned institutions.

Ideally, the PhD will start by a Master internship. During the internship, the student will work at LOA and will study, through theory and simulations, how x-ray and gamma-ray radiation produced by the particles in the plasma, a phenomenon called betatron radiation, can be used to understand the dynamics of the beam in the plasma and to help for reaching conditions suitable for the preservation of the beam brightness. The work can also include analysis of experimental data. The experimental development of a new plasma source with sharp density gradient will be considered with the goal of allowing the generation of ultrabright beam in beam-driven plasma acceleration experiments.

[1] I. Blumenfeld et al., Nature 445, 741 (2007)
[2] M. Litos et al., Nature 515, 92 (2014)
[3] S. Corde et al., Nature 524, 442 (2015)
[4] A. Doche et al., Scientific Reports 7, 14180 (2017)

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