Année universitaire/Academic year 2022-2023

PROPOSITION DE STAGE / INTERNSHIP PROPOSAL

Organisme/Institution : Institut Polytechnique de Paris / CNRS

Laboratoire/Laboratory : Laboratoire d'Optique Appliquée (LOA)

Adresse du lieu de stage/Lab address : 181 Chemin de la Hunière, 91120 Palaiseau

Responsable de stage/Supervisor : Cédric Thaury

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Internship conditions : legal stipend

Title : Theoretical study of superluminal laser-plasma acceleration

Abstract: As ionized media, plasmas are not subject to electrical breakdown and can thus withstand very high amplitude electric fields. This property is at the basis of laser-plasma accelerators. An intense laser pulse is focused into a light gas that turns into a plasma. The laser pulse then expels the plasma electrons out of its path and creates an ion cavity in its wake. The electric fields in this cavity are 3 to 4 orders of magnitude stronger than those obtained in conventional accelerators. Therefore, we can accelerate electrons to energies of a few giga-electronvolts ($v>0.9999999c$) in just a few centimeters, whereas this would require hundreds of meters with conventional techniques.

The maximum energy of these so-called wakefield accelerators is ultimately limited by the dephasing between the electron beam and the accelerating field. This dephasing comes from the velocity difference between the accelerating field and the electron beam, which causes the latter to leave the accelerator field after an acceleration of typically a few centimeters. This limitation could, in principle, be removed by controlling the velocity of the accelerating plasma wave, which requires the generation of an intense laser pulse that propagates in a vacuum at a superluminal velocity (> c). We recently produced such a pulse experimentally and numerically showed that it could dramatically increase the energy of the electrons produced through laser-plasma acceleration. However, many questions remain open: how to inject electrons into this accelerator, how to ensure that the laser keeps its unique properties in the plasma over long distances, and what is the energy efficiency of this accelerator...?

The internship objective is to study the propagation of a superluminal and ultra-intense pulse in a plasma using a numerical code developed in the laboratory. The results could be, at least partially, compared to analytical calculations. The internship could continue with a PhD during which the student will study superluminal laser-plasma acceleration using Particle-In-Cell simulations. Complex spatiotemporal couplings will be introduced to optimize the propagation of the laser or to locally slow down the pulse and thus control the injection of electrons into the accelerator. The student will also study the energy efficiency of this new accelerator concept using analytical and numerical approaches. Finally, he/she may explore the potential of ultra-intense superluminal pulses for other applications.

Possibilité de thèse **Oui**/~~Non~~ / Pursuing into PhD **Y**/~~N~~ ?

Contrat-financement probable / Expected contract-funding : IPP grant