SEMINAIRE LIDYL

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Le Jeudi 15 Décembre 2022 à 11h00
Orme des Merisiers, Bât.701, Pièce 17 (salle de séminaires)

The seminar will be accessible online on Zoom at the following address:
https://cnrs.zoom.us/j/93525599055?pwd=a0tTd1YwVGIzN1l4M0RNWlVQd0diQT09
Meeting ID: 935 2559 9055 / Passcode: 9g0TNY

Modeling a novel laser-driven electron acceleration scheme: Particle-In-Cell simulations at the exascale

I will present a novel laser-driven electron acceleration scheme that could find application in FLASH radiobiology experiments. Intense femtosecond lasers focused on low-density gas jets can accelerate ultra-short electron bunches up to very high energies over a few centimeters [1,2].

Among many possible applications, the compactness of these schemes and the shortness of the accelerated bunches make them a promising tool to study the so-called "FLASH effect". The FLASH effect consists in a reduced toxicity for normal tissues when irradiated at very high dose rates, which is very promising for cancer treatment, but also poorly understood, especially at ultra-short durations and ultra-high dose rates[3,4].
Conventional laser-driven electron acceleration schemes do not provide enough charge for radiobiology experiments. However, to address this issue, we have devised a novel laser-driven electron source consisting of a gas jet coupled to a plasma mirror, in order to accelerate substantially more charge. In 2022 we validated this concept with proof-of-principle experiments at the LOA laser facility (France), and with a numerical simulation campaign carried out on the most powerful supercomputers in the world. The technical and algorithmic challenges that we addressed to make these simulations possible earned us the Gordon Bell prize in 2022 [5].

Besides discussing our results on laser-driven electron acceleration, this seminar includes also a broad introduction to high-intensity laser-plasma interaction, its possible applications, and the numerical techniques used to model these plasmas. In particular, I will discuss the open-source Particle-In-Cell code WarpX[6,7]. WarpX is primarily developed by LBNL, LLNL, CEA-LIDYL, SLAC, DESY, CERN, and Modern Electron, and has been designed specifically to address the challenges of simulating kinetic plasma phenomena on exascale machines.

1. E.Esarey al. Rev.Mod.Phys. 81, 1229, 2009
2. W.P.Leemans et al. Phys.Rev.Lett. 113(24), 245002, 2014
3. V.Favaudon et al. Science. Trans. Med., 6, 245, 2014
4. J.Bourhis et al. Radioth. Oncol., 139, 18-22, 2019
5. L.Fedeli et al. 2022 SC22: International Conference for High Performance Computing, Networking, Storage and Analysis (SC). IEEE Computer Society, 2022
6. A.Myers et al. Parallel Computing 108:102833, 2021 7. https://ecp-warpx.github.io/ (WarpX github repository