Joint DESY and University of Hamburg Accelerator Physics Seminar

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ZOOM video seminar (needs version 5.8+)

Plasma Mirrors as a Path to The Schwinger Limit

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Abstract

Following the advent of PetaWatt (PW) class lasers, high-field science aims at solving major fundamental questions: How does light interact with matter or the quantum vacuum at intensities ($I \gg 10^{25}$ W/cm^2) where the physics is governed by Quantum Electrodynamics (QED)? What are the properties of the QED electron-positron pair plasma produced in those interactions? Can the probing of this plasma help address open problems in quantum field theory and astrophysics?

As the required intensities are orders of magnitude higher than the present record (10^{23} W/cm^2) held by a 4PW laser, solving these major questions with the current generation of lasers requires conceptual breakthroughs that I strived to address with my team during the last 5 years. To break this barrier, we proposed to revive an old concept called the "Curved Relativistic Mirror" (CRM). Assuming a perfectly reflective and aberration-free CRM, reflecting a high-power laser on such a relativistic mirror could in principle boost its intensities by several orders of magnitude through Doppler effect. The major obstacle with this simple concept has been its actual implementation: how to produce a curved and highly-reflective relativistic mirror of excellent optical quality in experiments? This has remained an open question so far, which has resisted all experimental attempts.

In this talk, I will present the theoretical and numerical efforts that my team and I have carried out at CEA to answer this question, starting from the development of the 3D kinetic code WarpX-PICSAR up to the very first numerical experiments of CRM designs performed with the code at very large scale. These experiments demonstrated that realistic and highly-robust implementations of a CRM can be achieved employing remarkable physical systems called "relativistic plasma mirrors", which can be obtained by focusing a high-power laser on an initially-solid target. Leveraging on these first results, we demonstrated that high-power PW lasers, boosted by a relativistic plasma mirror, can increase SF-QED signatures by orders of magnitude, potentially giving access to new physics at existing laser facilities. Our theoretical and numerical predictions have already been confirmed in the 100 Terawatt regime at CEA, showing that optically-curved plasma mirrors can spatio-temporally compress a high-power laser with an excellent optical quality. These first steps constitute key milestones in the future quest for the highest intensities using PW-class lasers.

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