LABORATOIRE INTERACTIONS, DYNAMIQUES ET LASERS

*LIDYL-UMR 9222*
*CEA, CNRS, Université Paris-Saclay*

# HDR LIDYL

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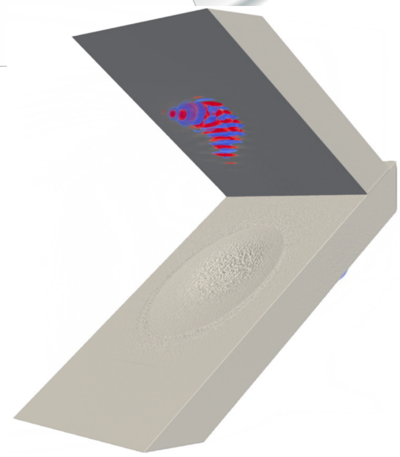
**Lundi 25 Octobre 2021, 14h00**
***Auditorium Pierre Lehmann de l'IJCLab d'Orsay***



*Snapshot from a 3D kinetic simulation showing the focusing of a high-power laser (color scale) by an optically-curved relativistic plasma mirror (gray-scale, lower target) on a secondary solid target (gray-scale, upper target) to induce SF-QED processes. Credit: Luca Fedeli – CEA.*

With the advent of PetaWatt (PW) class lasers already capable of achieving light intensities of $10^{22}$W/cm$^2$, at which matter turns into an ultra-relativistic plasma, high-field science now aims at solving a major challenge of modern physics: can we produce extreme light intensities above $10^{25}$ W/cm$^2$ beyond which yet unexplored Strong-Field Quantum Electrodynamics (SF-QED) regimes would dominate light-matter or even light-quantum vacuum interactions?

Reaching these SF-QED regimes in the lab would have a profound impact on the test of QED, the design of future TeV lepton colliders, the discovery of new physics beyond the standard model or the understanding of remote astrophysical objects such as blackholes, pulsar magnetospheres, and Gamma-Ray Bursts where relativistic quantum plasma states are pervasive and dominated by SF-QED processes.

However, as the required intensities are more than three orders of magnitude higher than the present record held by a PetaWatt (PW)-class laser, solving this major question with the current generation of high-power lasers requires conceptual breakthroughs that I strived to address with my team during the last 5 years.

To break this barrier, I 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 moving mirror could in principle boost its intensities by several orders of magnitude through Doppler effect. Of course, the major obstacle with this simple concept is 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 my habilitation thesis defense, 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 in collaboration with Berkeley Lab, up to the very first numerical experiments of CRM designs performed with the code at very large scale.

Using advanced 3D simulations on the largest supercomputers worldwide, we robustly demonstrated that optically-curved relativistic plasma mirrors (obtained when a high-power laser is focused on an initially flat solid target) are perfect candidates to implement a CRM. Our work has led to several conceptual designs of CRMs based on plasma mirrors that are now at the center of numerous experimental campaigns planned at PW-class laser facilities.

Leveraging on these first results, we showed 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 excellent optical quality. These first steps constitute key milestones in the future quest for the highest intensities using PW-class lasers.

*N.B: le nombre de participants sur site étant limité (70 max), merci de m'indiquer par réponse d'email (henri.vincenti@cea.fr) si vous participerez en présentiel. Le pass sanitaire est obligatoire. Si le quota de 70 est atteint, il y a toujours la possibilité de participer en visioconférence via le lien ci-dessous :*

*https://ijclab.zoom.us/j/91380180543?pwd=Sis3VHBDVWJDQkZCL2xDaG1KSVdLUT09*