Exploring Strong-Field QED with Doppler-Boosted Harmonic Beams: From Simulations to Experiments

L Fedeli[1], B Groussin[2], P Sikorski[1], P Bartoli[1], A Leblanc[2], and H Vincenti[1]

[1]*LIDYL, Université Paris-Saclay CEA Saclay, Gif Sur Yvette, France*
[2]*LOA, ENSTA, École Polytechnique, CNRS, Palaiseau, France*
Contact Email: luca.fedeli@cea.fr

Leveraging plasma mirrors to boost the intensity of Petawatt-class lasers is emerging as a key enabling technology to explore the strong-field regime of Quantum Electrodynamics (SF-QED). The boosting process relies on high-order Doppler harmonic generation with solid targets irradiated at ultra-high intensity, and on the tight focusing of the harmonic beam by the radiation pressure-induced curvature of the target surface[1]. Numerical simulations have suggested that conditions suitable to study SF-QED in yet unexplored regimes could be reached by focusing such Doppler-boosted beams onto solid targets[2] or relativistic particle beams[3].

In this contribution we will address crucial challenges and possible solutions to move from idealized numerical setups to concrete experimental designs, in particular: - High-order harmonic generation with Petawatt-class lasers is almost unexplored in experiments. In a recent campaign carried out at the BELLA (LBNL, USA) laser facility, we have observed that a careful control of the sub-picosecond temporal contrast of the driving laser pulse is critical to generate harmonics with high efficiency[4]. We will discuss the physical processes that can lead to a degradation of harmonic generation, as well as possible mitigation strategies. - The experimental study of SF-QED must rely on indirect observable quantities to infer the interaction parameters[5]. We will discuss which information can be extracted from energy spectra and angular distributions of high-energy photons, electrons, and positrons generated during the interaction of a Doppler-boosted beam with a target or a particle beam.

The numerical results presented in this contribution have been mainly obtained with the open-source, massively-parallel, Particle-In-Cell code WarpX[6].

References

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