Laser-induced vacuum birefringence beyond idealized setups

R. Torres[1], T. Grismayer[1], R.A. Fonseca[1,2], L.O. Silva[1]

[1] *GoLP/Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal*

[2] *DCTI/ISCTE - Instituto Universitário de Lisboa, 1649-026 Lisbon, Portugal*

The prospect of coupling ultra-intense lasers with x-ray sources (e.g. at SLAC or XFEL) will allow to perform the first experiments on probing the quantum vacuum. For this scenario, either an analytical solution cannot be found or the analytic methods are inefficient due to the increasing complexity coming from the setup or the electromagnetic profiles of the laser pulses. Consequently, we have developed a numerical method to self-consistently solve the nonlinear system of Maxwell's equations including quantum corrections of the vacuum polarization [1]. This will allow modelling future planned experiments aiming to measure the induced ellipticity on an x-ray pulse after probing a strong optical laser due to quantum vacuum fluctuations [2]. Realistically, experimental conditions are not ideal and one should study the impact of these imperfections in the signatures resulting from quantum electrodynamic processes. In this way, we will be able to optimize the experimental setup in order to perform the first direct detection of the photon-photon scattering. We present simulation results of the ellipticity induced for a set of non-ideal setups: misalignment of the central axis of the x-ray probe and the ultra-intense optical pump pulse, different polarization angles between the x-ray and optical laser pulses, temporal mismatch of the pulses focuses (timing jitter) and finite-size multi-dimensional effects [3]. This code has been benchmarked for simpler cases, giving us the confidence to tackle realistic setups. Ultimately, our code is capable of exploring regimes unachievable by a theoretical analysis, which is going to be of great utility for the extremely high-intensity laser physics society.

References

[1] P. Carneiro, T. Grismayer, R.A. Fonseca and L.O. Silva, arXiv:1607.04224v2 (2017)

[2] V. Dinu, T. Heinzl, A. Ilderton, M. Marklund, G. Torgrimsson, Phys. Rev. D **90**, 045025 (2014)

[3] B. King and C.H. Keitel, New J. Phys. **14**, 103002 (2012)