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QED multi-dimensional vacuum polarization finite-difference solver PEDRO CARNEIRO, THOMAS GRISMAYER, LUÍS SILVA, GoLP/IPFN, Instituto Superior Técnico, RICARDO FONSECA, DCTI/ISCTE-Instituto Universitário de Lisboa — The Extreme Light Infrastructure (ELI) is expected to deliver peak intensities of $10^{23} - 10^{24}$ W/cm^2 allowing to probe nonlinear Quantum Electrodynamics (QED) phenomena in an unprecedented regime. Within the framework of QED, the second order process of photon-photon scattering leads to a set of extended Maxwell's equations [W. Heisenberg and H. Euler, Z. Physik 98, 714] effectively creating nonlinear polarization and magnetization terms that account for the nonlinear response of the vacuum. To model this in a self-consistent way, we present a multi dimensional generalized Maxwell equation finite difference solver with significantly enhanced dispersive properties, which was implemented in the OSIRIS particle-in-cell code [R.A.Fonseca et al. LNCS 2331, pp. 342-351, 2002]. We present a detailed numerical analysis of this electromagnetic solver. As an illustration of the properties of the solver, we explore several examples in extreme conditions. We confirm the theoretical prediction of vacuum birefringence of a pulse propagating in the presence of an intense static background field [arXiv:1301.4918 [quant-ph]]. We also show the generation of high harmonics from the vacuum when two counter-propagating pulses interact for realistic beam setups in agreement with a theoretical calculation performed. By considering the finite structure of the fields, the results obtained serve as an important benchmark for experiments aimed at detecting nonlinear QED processes resorting to ultra intense lasers.

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