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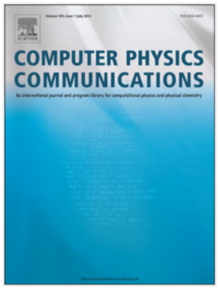

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H. Vincenti, J.-L. Vay

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Detailed analysis of the effects of stencil spatial variations with arbitrary high-order finite-difference Maxwell solver.

H. Vincenti[a,b,*], J-L Vay[a]

[a] *Lawrence Berkeley National Laboratory, 1 cyclotron road, Berkeley, California, USA*
[b] *Lasers Interactions and Dynamics Laboratory (LIDyL), Commissariat à l'Energie Atomique, Gif-Sur-Yvette, France*

Abstract

Very high order or pseudo-spectral Maxwell solvers are the method of choice to reduce discretization effects (e.g numerical dispersion) that are inherent to low order Finite-Difference Time-Domain (FDTD) schemes. However, due to their large stencils, these solvers are often subject to truncation errors in many electromagnetic simulations. These truncation errors come from non-physical modifications of Maxwell's equations in space that may generate spurious signals affecting the overall accuracy of the simulation results. Such modifications for instance occur when Perfectly Matched Layers (PMLs) are used at simulation domain boundaries to simulate open media. Another example is the use of arbitrary order Maxwell solver with domain decomposition technique that may under some condition involve stencil truncations at subdomain boundaries, resulting in small spurious errors that do eventually build up. In each case, a careful evaluation of the characteristics and magnitude of the errors resulting from these approximations, and their impact at any frequency and angle, requires detailed analytical and numerical studies. To this end, we present a general analytical approach that enables the evaluation of numerical errors of fully three-dimensional arbitrary order finite-difference Maxwell solver, with arbitrary modification of the local stencil in the simulation domain. The analytical model is validated against simulations of domain decomposition technique and PMLs, when these are used with very high-order Maxwell solver, as well as in the infinite order limit of pseudo-spectral solvers. Results confirm that the new analytical approach enables exact predictions in each case. It also confirms that the domain decomposition technique can be used with very high-order Maxwell solvers and a reasonably low number of guard cells with negligible effects on the whole accuracy of the simulation.

Keywords: 3D electromagnetic simulations, very high-order Maxwell solver, pseudo-spectral Maxwell solver, Domain decomposition technique, Perfectly Matched Layers, Effects of stencil truncation errors

*Corresponding author
Email addresses: hvincenti@lbl.gov (H. Vincenti), jlvay@lbl.gov (J-L Vay)