DGTD Using Parametric Variational Principle for Nonlinear Electromagnetic Simulations

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Conventional time domain computational electromagnetic algorithms may suffer from low efficiency, large error and even non-convergence when solving the response of nonlinear media in an iteration process. To deal with this difficulty, a novel nonlinear discontinuous Galerkin time domain (DGTD) method is proposed employing the parametric quadratic programming method for calculating the transient electromagnetic response of the instantaneous nonlinear media.

This proposed algorithm inherits the advantages of subdomain level DGTD method, such as domain decomposition, unstructured mesh, non-conformal interface, *hp*-refinement, and flexibility in time integration. (J. Chen and Q. H. Liu, Proceedings of the IEEE, 101.2, 242-254, 2013). With the help of domain decomposition method (DDM), only subdomains containing the nonlinear media requires additional treatments, and this will significantly reduce the computational resource overhead compared to algorithms without DDM, such as the finite-element time-domain method. Unlike conventional nonlinear finite-difference time-domain scheme, the proposed scheme is not based on iteration, but on the base exchanges in the solution of standard quadratic programming problem by transforming the nonlinear constitutive law to a set of linear complementary problems with parametric variables. In addition, the proposed approach is free of updating the system matrices in each time step.

Numerical cases with strong nonlinear media have been simulated, and the effectiveness of this new approach has been validated with accurate results and good convergence. This approach also has the potential to be applied to model nonlinear crystal and nano materials, such as $LiNbO_3$, $C_7H_7NO_2$ and optical metasurfaces.