DEVELOPMENT OF A SELF-CONSISTENT, TRULY MULTI-PHYSICS, ALGORITHM BASED UPON THE COURANT-INSENSITIVE, SPACE-TIME, CONSERVATION-ELEMENT/SOLUTION-ELEMENT METHOD

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This work reports on the theoretical aspects and current development status of a self-consistent, truly multi-physics algorithm. The algorithm is based upon the courant insensitive, space-time, conservation-element / solution-element (CICE/SE) methodology [1-2]. Previous attempts for electromagnetic solutions have applicability only in constant material domains with PEC boundary conditions [3]. Recent work by the authors [4-5] has extended this algorithm for solution of the generalized Maxwell equations, including dispersive materials. This sets the problem space of solution to any physical system that may be cast into conservative, hyperbolic form. The numerical solution is shown to be extremely accurate on highly non-uniform meshes and reduces to the classical 2,2-FDTD error properties in the uniform cartesian grid limit. Validation problems and comparison with the ubiquitous baseline FDTD algorithm will be presented in 1D (2D space-time). Results show that the 2^{nd} order CE/SE method has accuracy equivalent to 4^{th}-6^{th} order FDTD for equal grids with highly discontinuous coefficients (e.g. permittivity). Progress on extensions to multi-spatial dimensions and PIC/Vlasov solutions will also be reported. Applications for generic multi-scale physic simulations, along with head-to-tail calculations for vacuum electronic device simulation (including simultaneous heat transfer at body walls) will also be discussed.

[1] Chang, S.C. and To, W.M., NASA TM 104495, August 1991.
[2] Chang, S.C., Courant Number and Mach Number Insensitive CE/SE Euler Solvers, AIAA Paper 2005-4355, 41st AIAA/ASME/SAE/ASME Joint Propulsion Conference and Exhibit, July 11-13, 2005, Tucson, AZ.
[3] Wang, X.Y., et.al., "The Space-Time CE/SE Method for Solving Maxwell's Equations in Time-Domain," 2002 IEEE International Symposium on Antennas and Propagation and the USNC/URSI National Radio Science Meeting, June 16th-21st, San Antonio, TX.
[4] Sessions, W.D. and DeVault, K.J., "Solution of the Generalized Maxwell's Equations with the Courant-Insensitive Space-Time Conservation-Element Solution-Element Method Part I: Linear Non-Dispersive Materials," NSWCDL 2009 Preprint under DoD review for submission to the Journal of Computational Physics.
[5] Sessions, W.D. and DeVault, K.J., "Solution of the Generalized Maxwell's Equations with the Courant-Insensitive Space-Time Conservation-Element Solution-Element Method Part II: Linear Dispersive Materials," NSWCDL Draft paper 2009.

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