A joint seminar by ELECTRICAL ENGINEERING AND COMPUTER SCIENCE - ENGINEERING SCIENCES & APPLIED MATH

Bringing Astrophysics Down to Earth: The Development of a New Generation of High-Accuracy Methods for Computational Electrodynamics

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The numerical solution of Maxwell's time-dependent equations plays a very useful role in electrical engineering as well as physical chemistry and photonics at the nanoscale. Maxwell's equations constitute an involution-constrained PDE system and computational electrodynamics (CED) has been developed into a high art by electrical engineers. The highly popular, and very successful, finite-difference time-domain (FDTD) scheme can mimetically fulfill the goals of global constraint preservation. However, FDTD does not extend seamlessly to higher orders. This is one of its major limitations. A new generation of engineering CED applications demands high accuracy, and FDTD does not live up to that goal.

Computational astrophysicists do not use CED techniques that much. However, the inclusion of Faraday's law in magnetohydrodynamics (MHD) means that astrophysicists initially drew greatly on the methods that were developed by electrical engineers. The new methods for numerical MHD by this author surpassed the second-order accuracy of FDTD. Consequently, engineers were now in need of these high-accuracy innovations that had already gestated in the field of astrophysics. It is now time to make a reverse technology transfer from astrophysics to electrical engineering. The author of this talk has been on the forefront of the MHD innovations and will describe how, through his leadership, the same innovations are now finding their way back into CED!

The goal of this talk is to present recently innovated finite-volume time-domain (FVTD) and discontinuous-Galerkin time-domain (DGTD) schemes that are indeed the closest high-order analogues of FDTD. They represent a confluence of three leading-edge innovations which were first made in numerical MHD: **1)** The new methods use constraint-preserving WENO and DG reconstruction. **2)** The methods also utilize multidimensional Riemann solvers so that the global constraints are satisfied on the same control volume. **3)** To treat stiff source terms, PML and ADEs, we also recast ADER methods. A von Neumann stability analysis shows that our methods have superior wave propagation properties. Our PNPM schemes also work at large CFL number.

The proposed new techniques lay a firm foundation for the entire discipline of 21st century CED, leading to advances across multiple disciplines.

Note: Cookies will be served at 3:30