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2P29 - Fast A-Stable Implicit Scheme and Scalable Software MOLTN For Electromagnetics

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Maxwell's equations based vector potential formulation of electromagnetism is widely used in classical and quantum physics. However, in PIC simulations, the community has primarily focused on Maxwell's equations in first-order form, exploiting the explicit Yee method for the fields with the Boris push for the particles. However, a challenge with this approach is geometry. The community has embraced CUT cells as a solution, however, both particle weighting and field updates on cut cells are problematic and the approximations used together can lead to instabilities, and the fields introduce a stability issue in terms of restrictive CFL. In this work, we are developing a new approach to overcome these issues, based vector potential formulation under the Lorenzo gauge. The scheme is based on the MOLT which first discretizes the operator in time and then solves the resulting boundary value problem using a kernel method. It is fast (O(N)), linear-time, high-order in space and A-Stable to all orders in time. ADI scheme is used for the extension to multi-dimensions, with each line solved independently. High-order is achieved using successive convolution to correct for the splitting error. It avoids the use of matrices, eliminating the main bottleneck in scaling implicit methods. An embedded boundary method is employed to deal with complex geometries, and It does not suffer from small time step limitations. The eventual goal is to combine this method with a novel particle method for the simulations of plasma. So far, the consistency and performance of the scheme are evaluated for EM wave propagation and scattering using different shaped objects including curved boundaries, and the introduction of true point sources that demonstrate how we will look to handle particles. We are developing an open-source code MOLTN which is hardware-independent, scalable software tool, using multi-node MPI, multi-core OpenMP, and GPU Cuda implementation.

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