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**FDTD simulation of fusion plasmas at RF time scales.**[1]

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Simulation of dense plasmas in the RF frequency range are typically performed in the frequency domain, i.e., by solving Laplace-transformed Maxwell's equations. This technique is well-suited for the study of linear heating and quasi-linear evolution, but does not generalize well to the study of non-linear phenomenon. Conversely, time domain simulation in this range is difficult because the time-scale is long compared to the electron plasma frequency, yet the waves still have appreciable electromagnetic character. Thus, a full set of Maxwell equations is needed, but one cannot afford a time-step small enough to resolve the full physics of the plasma. A long time step, coupled with the various cutoff and resonance behaviors within the plasma, insure that an explicit finite-difference scheme would be numerically unstable. To resolve this dilemma, we introduce a locally implicit method to treat the plasma current, while preserving the performance of explicit finite-difference for the Maxwell terms. Careful time-centering provides an energy conserving algorithm that will faithfully reproduce all CMA-diagram dispersion behavior, at the available temporal and spatial resolution, despite the fact that the simulation time-step may exceed the electron gyro and electron plasma time scales by orders of magnitude. The remaining stability criterion is the vacuum speed-of-light Courant condition. We plan to couple this implicit algorithm, as a noise-free background plasma, to a particle-in-cell method, in order to provide more effective study of kinetic and non-linear effects. We present 3-D demonstrations of the method for several classical benchmarks, including mode-conversion to ICW (ion cyclotron wave), cyclotron resonance, propagation into a plasma-wave cutoff, and tunneling through low density edge plasma.

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