Discussion of the properties of an implicit-explicit Runge-Kutta scheme that strictly satisfies Gauss's laws for the full two-fluid plasma model

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In a previous study we developed a new numerical scheme for the full two-fluid plasma model. The full two-fluid plasma model solves one set of Euler equations for each the ion and electron fluid, while the electromagnetic fields are evolved in time using Maxwell's equations. Gauss's laws are strictly satisfied by arranging the electric and magnetic fields in a staggered grid and discretizing Maxwell's equations with a central differencing scheme analogous to the FDTD method [1]. The fluid equations are solved with the HLLC approximation Riemann solver [2]. For the time development we implemented an implicit-explicit Runge-Kutta method. By calculating the stiff source terms implicitly, rapid oscillations, that happen on a time scale irrelevant to the problem, which is to be solved, are excluded and thereby numerical stability improves.

In this study we discuss the properties of the developed numerical scheme by evaluating the results of several numerical experiments including standard problems such as the electron plasma oscillation, the ion acoustic soliton and the Brian-Wu Shock Tube. We furthermore consider possible extensions to the model that would allow for applications to phenomena of the upper atmosphere such as auroral acceleration zones.

References

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