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[1];   [2];   [3]
[1] IFREE, JAMSTEC; [2]   STE   ; [3]

Development of Multi Moment Advection (MMA) Schemes in Multidimensions for Electromagnetic Vlasov Simulations

Takashi Minoshima[1]; Yosuke Matsumoto[2]; Takanobu Amano[3]
[1] IFREE, JAMSTEC; [2] STEL, Nagoya Univ.; [3] Dept. Phys., Nagoya Univ.

We have developed Multi Moment Advection (MMA) schemes to numerically solve the advection equation and applied them to Vlasov simulations. The MMA solves the time evolution of piecewise values of the zeroth to second order momenta as well as the distribution function, allowing us to follow a long time evolution of the distribution function with little numerical diffusion.

For electromagnetic Vlasov simulations, it is necessary to solve the solid rotation (gyro motion) as well as the linear advection (acceleration by electric fields) in the multi-dimensional velocity space. Even with previously-proposed high order schemes such as the CIP (Yabe et al., 1991) and back substitution (Schmitz and Grauer, 2006) schemes, it is difficult to solve the solid rotation problem for a long time due to a significant numerical diffusion. To overcome this difficulty in solving the multi-dimensional problem, we have developed the two- and three-dimensional MMA schemes (MMA2D and MMA3D). As a result, the MMA provides an unprecedented high accuracy solution of the solid rotation problem. Applying the MMA2D to the advection in the velocity space, we have succeeded in the electromagnetic Vlasov simulation with highly keeping the mass and energy conservations.

In this presentation, we show details of the MMA2D and its application to the electromagnetic Vlasov simulations, such as Bernstein modes, Harris current sheets, and perpendicular shocks. We also report the progress of the development of the MMA3D.