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Extended Magnetohydrodynamics with Embedded Particle-in-Cell (XMHD-EPIC) Simulations of Magnetospheric Reconnection

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We have recently developed a new modeling capability to embed the implicit Particle-in-Cell (PIC) model iPIC3D into the BATS-R-US extended magnetohydrodynamic model. The PIC domain can cover the regions where kinetic effects are most important, such as reconnection sites. The BATS-R-US code with its block-adaptive grid can efficiently handle the rest of the computational domain where the MHD or Hall MHD description is sufficient. The current implementation of the MHD-EPIC model allows two-way coupled simulations in two and three dimensions with multiple embedded PIC regions. The MHD and PIC grids can have different grid resolutions and grid structures. The MHD variables and the moments of the PIC distribution functions are interpolated and message passed in an efficient manner through the Space Weather Modeling Framework (SWMF). Both BATS-R-US and iPIC3D are massively parallel codes fully integrated into, run by and coupled through the SWMF.

We have successfully applied the MHD-EPIC code to model Ganymede's and Mercury's magnetospheres. We compared our results with Galileo and MESSENGER magnetic observations, respectively, and found good overall agreement. We will report our progress on modeling the Earth magnetosphere with MHD-EPIC with the goal of providing direct comparison with and global context for the MMS observations.