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Magnetosheath dynamics and lobe reconnection as seen from a global beyond-MHD simulation Vlasiator

M. Palmroth, I. Honkonen, Y Kempf, S von Alfthan, and A Sandroos
Finnish Meteorological Institute, Earth Observation, Helsinki, Finland (minna.palmroth@fmi.fi)

Global magnetohydrodynamic (MHD) simulations have been successful in describing systems where the important spatial scales are larger than ion gyro radii and the plasma has a well-defined temperature. The weakness of global MHD simulations is their inability to model the multi-temperature, multi-component plasmas in the inner magnetosphere, where most of space-borne technology, including communication and navigation systems reside. We are developing a global Vlasov-hybrid simulation called the Vlasiator, where electrons are massless MHD fluid, but protons are modelled as distribution functions evolved in time using the Vlasov equation. This approach does not include the noise present in kinetic-hybrid simulations, but is computationally extremely challenging requiring petascale computations with thousands of cores. Here, we briefly review the status of the new six-dimensional Vlasiator. We carry out a test particle simulation and propagate the distribution functions using the electromagnetic fields of the GUMICS-4 global MHD simulation. We test and validate Vlasiator in a global setup by comparing the results from the test particle simulation against the standalone GUMICS-4 global MHD simulation. We find that the magnetosheath and magnetopause plasma properties from the test particle simulation are in rough agreement with the results from the GUMICS-4 simulation; however, also important differences arising from the kinetic treatment of plasma are observed. These beyond-MHD effect include the magnetosheath flow pattern changes after a newly established lobe reconnection within one hemisphere.