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Large-scale kinetic simulation of the magnetosphere

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Vlasiator is a newly developed, global hybrid-Vlasov simulation, which solves the six-dimensional phase space utilising the Vlasov equation for protons, while electrons are a charge-neutralising fluid. The outcome of the simulation is a global reproduction of ion-scale physics. Vlasiator produces the ion distribution functions and the related kinetic physics in unprecedented detail, in the global scale magnetospheric scale with the resolution required by kinetic physics. Here, we review the recent progress made in the Vlasiator development, highlight newest physical findings, and look forward to future challenges by presenting our upcoming new project awarded by the European Research Council.

Specifically, we investigate the dayside-nightside coupling of the magnetospheric dynamics. Here, we run Vlasiator in the 5-dimensional (5D) setup, where the ordinary space is presented in the 2D noon-midnight meridional plane, embedding in each grid cell the 3D velocity space. The simulation is during steady southward interplanetary magnetic field. We observe dayside reconnection and the resulting 2D representations of flux transfer events (FTE). In the nightside, the plasma sheet first shows slight density enhancements moving slowly earthward. Second, the tailward side of the dipolar field stretches. Strong reconnection initiates first in the near-Earth region, forming a tailward-moving magnetic island that cannibalises other islands forming further down the tail, increasing the island's volume and complexity. After this, several reconnection lines are formed again in the near-Earth region, resulting in several magnetic islands. We investigate this substorm process holistically as a result of dayside-nightside coupling. In particular, we concentrate on the role of the FTE's in the magnetospheric dynamics.