Particle energisation and energy transport in Multiscale MHD - Hybrid - Kinetic PIC models of magnetospheres

Giovanni Lapenta\textsuperscript{1}, Jean Berchem\textsuperscript{2}, Raymond Walker\textsuperscript{2}, Mostafa El Alaoui\textsuperscript{2}, David Schriver\textsuperscript{2}, Robert Richard\textsuperscript{2}, and Pavel Travnicek\textsuperscript{3}

\textsuperscript{1}KU Leuven, Center for Mathematical Plasma Astrophysics, Wiskunde, Leuven, Belgium (giovanni.lapenta@kuleuven.be)
\textsuperscript{2}UCLA
\textsuperscript{3}Astronomical Institute, CAS, Bocni II/1401, CZ-14100 Prague, Czech Republic

A grand challenge in physics is to understand how and where electrons and ions accelerate to high energy, often forming power law distributions. We report the result of a combined kinetic-fluid effort [1]. For Earth, a full kinetic model of sizeable chunks of the magnetosphere (e.g. the magnetopause up to the bow shock, or the magnetotail) of order 10-20 RE in size in each dimension is hosted within a MHD simulation that provides it with initial and boundary conditions. For Mercury, it is possible to treat the whole magnetosphere that in this case is spawn from a state derived from a hybrid code [2].

With this approach, we search for regions of most intense particle heating and acceleration, comparing the full kinetic (i.e. we treat both electrons and ions as particles) evolution with the evolution of the host global simulation: MHD for the Earth and hybrid for Mercury.

The results highlight some significant effects peculiar to kinetic models. First, of all full kinetic models provide a detailed view of the electron role in energy transfer, with a distinct role for the enthalpy, bulk and heat flux. Second, the full kinetic approach, allows for the development of modes and instabilities absent in global fluid or hybrid models [3].