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Electron dynamics in Mercury's magnetosphere using a global fully-kinetic model

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Mercury is the only telluric planet of the solar system, other than Earth, with an intrinsic magnetic field. Thus, the Hermean surface is shielded from the impinging solar wind via an "Earth-like" magnetosphere. This magnetic cavity is however twenty times smaller than its counterpart at the Earth and Mercury occupies a large portion of this cavity. The relatively small extension of the Hermean magnetosphere enables global numerical modeling of this system. Past modeling efforts have addressed both fluid and ion kinetic plasma physics, therefore supporting past *in-situ* plasma observations at Mercury by the NASA MESSENGER mission. Inspired by the wealth of observations provided by MESSENGER, the ongoing ESA/JAXA BepiColombo mission started probing the plasma environment around Mercury with a devoted instrumental suite targeting for the first time the electron kinetic physics. To interpret ongoing – and prepare future – BepiColombo observations of Mercury's magnetosphere, global simulations of the Hermean environment including electron kinetic physics are crucial.

The goal of this work is to self-consistently study the global electron dynamics in the Hermean magnetosphere. A particular focus is given to (i) electron acceleration and heating as a consequence of magnetic reconnection, (ii) electron circulation in the Hermean dipolar magnetic field and, finally, (iii) precipitation of electrons on Mercury's surface. The investigation of such processes requires a dynamical model encompassing a wide range of temporal and spatial scales going from the large planetary (fluid) scales down to the small electron (kinetic) scales.

To this purpose, we present three-dimensional, fully-kinetic simulations of the interaction between the solar wind plasma and Mercury's dipole magnetic field. This model self-consistently includes plasma processes from the large planetary scale down to the electron scale. Such simulations are performed with the implicit, full-PIC code iPIC3D.

From the analysis of our global simulations, we find the following results. (i) Magnetic reconnection in the tail accelerates and heats electrons up to tens of keV in the case of southward interplanetary magnetic field (IMF). These electrons are ejected from the neutral line in the tail planet-ward in a substorm fashion. (ii) Such substorm electrons drift dawn-ward from the nightside around the planet, forming a quasi-trapped population. Noticeably, most of these electrons fall on the planet surface before completing a full longitudinal orbit. We also show comparisons between our simulations and *in-situ* observations by Mariner10 and BepiColombo space missions. We argue that these electrons have been observed *in-situ* by the PLS instrument onboard Mariner10 during its first Mercury flyby around and after closest approach. A similar electron population, although fainter, have been observed by the MPPE/MEA instrument onboard BepiColombo in the nightside magnetosphere. (iii) Eventually, electrons fall on Mercury's surface and interact with it. We show maps of electron precipitation on Mercury's surface and discuss them in comparison with observations of Calcium X-ray fluorescence emission from the surface by the XRS instrument onboard MESSENGER. This paves the way to the understanding of future X-ray observations of Mercury's surface by the MIXS instrument onboard BepiColombo, as a signature of plasma-surface interaction at Mercury.