



Mutual impedance and quasi-thermal noise to measure electron properties at Mercury: merging simulations of the magnetosphere and of the instrumental apparatus

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Mercury is the only telluric planet of the solar system, apart from Earth, possessing an intrinsic magnetic field. This magnetic field influences the dynamics of the solar wind plasma impinging on the planet, forming a magnetosphere. Mercury's magnetosphere has been investigated by multiple space missions in the past, notably the NASA Mariner10 and MESSENGER missions, and is today the target of the joint ESA/JAXA BepiColombo mission, currently en route, with orbit insertion scheduled for December 2025. BepiColombo instruments will observe for the first time the electron kinetic physics at Mercury. In order to interpret and plan BepiColombo's in-situ observations, an interplay is needed between numerical simulations of Mercury's magnetosphere and instrumental modelling.

In this work, we present a study of the expected instrumental response of the PWI/AM2P and PWI/SORBET experiments onboard BepiColombo, based on a two-step, fully-kinetic numerical approach.

First, we run fully-kinetic, three-dimensional, global simulations of the interaction between Mercury's magnetic field and the solar wind using the implicit particle-in-cell code iPIC3D. Non-maxwellian electron distribution functions are observed in the simulations.

Second, we use the electron distribution function derived from the previous step as input for a numerical model of the electric antennas used by both the AM2P and SORBET experiments onboard the JAXA Mio craft (part of BepiColombo). The influence of the spacecraft and antennas geometries is included self-consistently in this second step.

Our 3D full-PIC simulations show that magnetic reconnection in the tail accelerates and heats electrons up to energies of few keVs when the interplanetary magnetic field (IMF) is southward. Such high-energy electrons are ejected from the neutral line in the tail planetward in a substorm-like process, leading to strong particle precipitation in the nightside of Mercury, especially at local time 0-6 h. Double Maxwellian electron distribution functions are inferred from the simulations in the nightside of Mercury (with temperature and density ratio of order 10 and 0.1-1, respectively).

We investigate the possibility of detecting these two Maxwellian populations using the AM2P and SORBET experiments, operating at Mercury after orbit insertion. We also explore regions where the AM2P experiment can be calibrated in-flight.