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Electron acceleration by the lower-hybrid-drift instability at Mercury: an extended quasilinear model

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Density inhomogeneities are ubiquitous in space and astrophysical plasmas, in particular at contact boundaries between different media. They often correspond to regions that exhibit strong dynamics on a wide range of spatial and temporal scales. Indeed, density inhomogeneities are a source of free energy that can drive various plasma instabilities such as, for instance, the lower-hybrid-drift instability which in turn transfers energy to the particles through wave-particle interactions and eventually heats the plasma. Here, we address the role of this instability in the Hermean plasma environment where kinetic processes of this fashion are expected to be crucial in the plasma dynamics and have so far eluded the measurements of past missions (Mariner-X and MESSENGER) to Mercury.

The goal of our work is to quantify the efficiency of the lower-hybrid-drift instability to accelerate and/or heat electrons parallel to the ambient magnetic field.

To reach this goal, we combine two complementary methods: full-kinetic and quasilinear models. We report self-consistent evidence of electron acceleration driven by the development of the lower-hybrid-drift instability using 3D-3V full-kinetic numerical simulations. The efficiency of the observed acceleration cannot be explained by standard quasilinear theory. For this reason, we develop an extended quasilinear model able to quantitatively predict the interaction between lower-hybrid fluctuations and electrons on long time scales, now in agreement with full-kinetic simulation results. Finally, we apply this new, extended quasilinear model to a specific inhomogeneous space plasma boundary: the magnetopause of Mercury, and we discuss our quantitative predictions of electron acceleration in support to future BepiColombo observations.