Whistler-mode waves in the tail of Mercury's magnetosphere: A numerical study

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Résumé

Mercury hosts a small, highly dynamic magnetosphere in which magnetic reconnection plays a fundamental role in driving energy transfer and plasma dynamics. During its Mercury flybys, BepiColombo/Mio has already observed whistler-mode chorus waves, yet the underlying generation mechanisms and their global distribution remain poorly understood. We investigate these processes using a fully kinetic three-dimensional global simulation of the Hermean magnetosphere performed with the iPIC3D code, modeling the solar wind interaction under southward interplanetary magnetic field conditions, allowing to maximize magnetic coupling between the solar wind and the planet. Our simulation reveals that magnetic reconnection in the magnetotail drives significant wave activity originating near the diffusion region and propagating at large scales across the nightside magnetosphere. We show that high-energy electrons above 1 keV remain confined to closed magnetic field line regions, while lower-energy electrons populate both open and closed topologies, establishing a clear link between magnetic topology and electron energy distribution. In the vicinity of the diffusion region, we identify narrowband whistler-mode waves propagating nearly parallel to the background magnetic field at f∼0.5fce, exhibiting both electromagnetic and electrostatic components. A strong electron temperature anisotropy is identified as the likely free energy source driving wave growth. Once generated, these whistler waves propagate along the separatrices and resonantly interact with the local electron population. Our findings are discussed in the context of BepiColombo observations, offering a physical interpretation of the detected wave signatures and providing testable predictions for future measurements by the Mercury Magnetospheric Orbiter.

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