Thesis subject

Laboratory: PIIM UMR 7345

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Co-supervisor:

Title of the thesis subject: The interaction of Mercury with the interplanetary medium: Kelvin-Helmholtz instability at Mercury's magnetopause

Description of the thesis subject:

Kelvin-Helmholtz (KH) vortices results from the evolution of shear flows. They are quite ubiquitous in planetary magnetospheres and are one of the main mechanisms responsible for the plasma mass and energy transport observed across magnetospheric frontiers [1]. They have been intensively observed and investigated in the Earth's magnetospheric context, where their characteristic, fluid scales are larger than the ion Larmor radius. On the contrary, at Mercury, not only the observed KH scale but also the magnetosphere size is comparable with the ion Larmor radius, suggesting a plasma behaviour that is dominated by ion kinetic effects [2]. This behaviour could explain the important asymmetry, reported by the NASA MESSENGER space mission, in the development of KH vortices at the Dawn and Dusk magnetospheric flanks. This asymmetry could be consistent with strong kinetic effects [3] that are not specular (with respect to the reflection about the plane defined by solar wind direction and Mercury's dipole direction).
The Ph.D. student will investigate the linear and non-linear development of the boundary between the interplanetary medium (the so-called solar wind) and the Hermean plasma (magnetosphere), in particular the development of the KH instability, in Dusk/Dawn configurations, with the aid of a Hybrid Kinetic numerical, co-developed in collaboration with the Lagrange laboratory in Nice. This code treats the ions via an eulerian implementation of the collisionless Vlasov equation, self-consistently coupled to Maxwells' equations, while electrons are described as a neutralizing fluid, that includes the effects of finite electron mass [4], finite Larmor radius effects and non-collisional heat fluxes along magnetic field lines [5]. This work will prepare a solid scientific background on the Mercury's flank dynamics, in particular for the upcoming data analysis of the ESA BepiColombo space mission that will reach Mercury in 2025 [6].

References :

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[3] J. Paral et al., Nat. Commun. 4, 1645 (2013).
[4] F. Califano et al., Front. Phys. 8, 317 (2020).
[5] T. Passot et al., J. Plasma Phys. 83, 715830402 (2017).
[6] A. Milillo et al., Planet. Space Sci. 58, 40 (2010).