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Reconstruction of propagating Kelvin–Helmholtz vortices at Mercury’s magnetopause

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Abstract:

A series of quasi-periodic magnetopause crossings were recorded by the MESSENGER spacecraft during its third flyby of Mercury on 29 September 2009, likely caused by a train of propagating Kelvin–Helmholtz (KH) vortices. We here revisit the observations to study the internal structure of the waves. Exploiting MESSENGER’s rapid traversal of the magnetopause, we show that the observations permit a reconstruction of the structure of a rolled-up KH vortex directly from the spacecraft’s magnetic field measurements. The derived geometry is consistent with all large-scale fluctuations in the magnetic field data, establishes the non-linear nature of the waves, and shows their vortex-like structure. In several of the wave passages, a reduction in magnetic field strength is observed in the middle of the wave, which is characteristic of rolled-up vortices and is related to the increase in magnetic pressure required to balance the centrifugal force on the plasma in the outer regions of a vortex, previously reported in computer simulations. As the KH wave starts to roll up, the reconstructed geometry suggests that the vortices develop two gradual transition regions in the magnetic field, possibly related to the mixing of magnetosheath and magnetospheric plasma, situated at the leading edges from the perspectives of both the magnetosphere and the magnetosheath.