その場観測を用いた磁気圏界面ケルビン・ヘルムホルツ波の同定

長谷川 洋 [1]
[1] JAXA・宇宙研

On the identification of magnetopause Kelvin-Helmholtz waves from in situ observations

Hiroshi Hasegawa[1]
[1] ISAS/JAXA

The Kelvin-Helmholtz (KH) instability at planetary magnetopauses could play a pivotal role in the transfer of mass, momentum, and energy from the solar wind into the magnetospheres. However, since the resultant KH vortices have a complex, inherently two-, or occasionally three-, dimensional structure, it is not a trivial task to identify them and reveal their effects with in situ measurements. Here we summarize several criteria, a combination of which can be used to unambiguously detect magnetopause KH vortices. Their signatures that can be identified even from single-spacecraft data are (1) quasi-periodic oscillations in the magnetic field and/or plasma parameters, especially in the component normal to the nominal magnetopause of the velocity or mass flux, Vn or n$*$Vn, (2) their amplitude becoming smaller with distance from the boundary, (3) significant variations (spatial gradient) in the total (magnetic plus thermal) pressure to balance the centrifugal force exerted by the vortex flows (Miura, 1997; Hasegawa et al., 2009), and (4) a tailward flow of low-density, magnetospheric plasmas with a speed higher than the high-density magnetosheath flow (Hasegawa et al., 2006). These single-spacecraft methods can be applied to, e.g., data from planetary missions which usually make single-point measurements. Multi-spacecraft measurements and associated data analysis techniques, such as four-spacecraft timing method, have an advantage in providing evidence for overturning, viz., roll-up of the KH waves. The structural properties, such as the aspect ratio, of the KH vortices, can be used to estimate the KH-wave amplitude, information on which may be obtained by Grad-Shafranov-like reconstruction of streamlines (Hasegawa et al., 2007).

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