On the Dawn-Dusk Asymmetry of the Kelvin-Helmholtz Instability Between 2007 and 2013

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Motivation & Background

Cold component ions are observed to be 30–40% hotter and more abundant on the dawn side when compared to the dusk side of the plasma sheet (Wing et al., 2005). One of the possible sources of this is an asymmetry of the physical processes occurring on the magnetopause—the boundary layer between the Magnetosheath and the magnetosphere.

One such process is the Kelvin-Helmholtz Instability (KHI), which occurs when a high velocity shear exists on a boundary layer between two fluids of different densities. To explore this, a statistical study was performed using data from the virtual OMNI-ML observatory and the Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission.

Methodology

To categorize the IMF orientation as being PS, OPS, northward (NIMF), or southward (SIMF), the following conditions were imposed on the magnetic field given by the virtual OMNI-ML observatory and the Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission.

I. Parker spiral if \( B_y > 0.4B_z \) and \( B_y < -0.4B_z; \) or if \( B_y < -0.4B_z \) and \( B_z > 0.4B_y; \)

II. Ortho-Parker spiral if \( B_y > 0.4B_z \) and \( B_y > 0.4B_z; \)

III. northward if \( B_y > 0.5B_z; \) and

IV. southward if \( B_y < -0.5B_z\).

The KH onset condition (Chandrasekhar, 1961) was rearranged to be

\[
\frac{\tan \theta}{\frac{1}{n_{msh}} + \frac{1}{n_{mp}} + \frac{1}{B_{msh} \cdot k^2} + \frac{1}{B_{mp} \cdot k^2}} > 1
\]

maximized w.r.t. the angle of propagation. The components of \( \mathbf{V} \) and \( \mathbf{B} \) on \( \theta \) were then used to determine the KHI propagation angle.

The list of events from Kavosi & Raeder (2015) was used for identifying the observing spacecraft and the time and date when the KH events were observed, and the following was used to account for the time lag between OMNI and THEMIS data sets:

\[
\tau = \frac{\Delta \text{time}}{V_{msh} \cdot r}
\]

Conclusions

The main conclusions to be drawn from this are as follows:

1. There is an overall preference for the dawnside for KHI events.
2. The KH events are observed at the dusk sector for higher SW speeds.
3. During PS IMF, there is a significant preference to the dawn flank of the magnetopause.
4. A preference to dusk is suggested for OPS, but more data will need to be collected before proper conclusions may be drawn.

5. The weighted occurrence rates of the KHI show preference for the dusk during NIMF.
6. Average magnitude of the angle, \( \theta \), between KH wave vector and velocity shear vector is larger at the dusk sector for all IMF conditions than that at the dusk sector.

These results show that dawn flank preference of the KHI during PS orientation strongly support the idea that dawn-favored asymmetry of the density and temperature of the cold component plasma sheet ions is driven by asymmetric development of the KHI. Both reconnection in KH vortices (Nishimoto et al., 2007; Nykyri et al., 2016) and ion-scale wave generation by the KHI (Johnson & Cheng, 2001; Johnson et al., 2001; Moore & Nykyri, 2017; Moore et al., 2016) has been linked to ion heating.

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References


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