Magnetic Reconnection Associated with the Kelvin-Helmholtz Instability at Different Positions Along the Flank Magnetopause

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1. Introduction

- Solar wind flowing past the flank magnetopause forms waves that roll into vortices called the Kelvin-Helmholtz Instability (KHI) (Figure 1)
- As the waves propagate, they get increasingly rolled up and complex
- Magnetic reconnection is a process that transports matter and energy across the magnetopause boundary
- Happens when antiparallel field lines are pinched together and reorient themselves (Figure 2)
- Magnetic reconnection is thought to be a possible consequence of the KHI[1]
- We researched a relation between rolled up state of the waves and reconnection frequency (Figure 3)

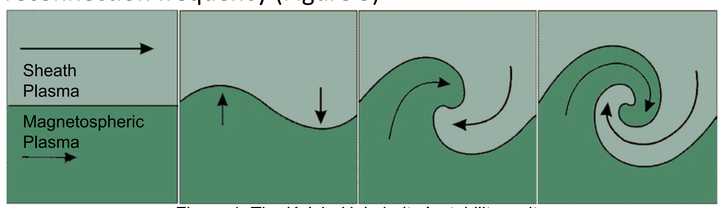

Figure 1, The Kelvin-Helmholtz Instability as it forms and grows along the magnetopause

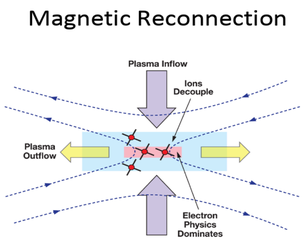

Figure 2, A diagram showing how antiparallel field lines reconnect to form a new orientation and releasee plasma jets

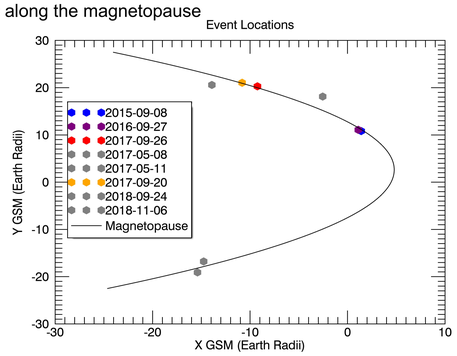

Figure 3, Events we found along the magnetopause. Ones further down (the negative x direction) are more rolled up The ones we actually studied are in color

Acknowledgements

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2. Methods

- NASA's Magnetospheric Multiscale Mission (MMS) was made to study reconnection
- Regularly crosses the magnetopause
- Can cross through KHI regions (Figure 4)
- We looked through MMS data for signatures of reconnection like directional reversals of the magnetic field, ion jets, and enhanced electromagnetic energy conversion (Figure 5)

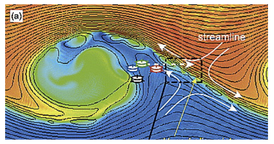

Figure 4, MMS satellites as KHI waves flow over them. Since they move much slower than the waves, we can act like they are stationary. So they see cool magnetosheath plasma, then warmer plasma periodically.

3. Results

- Each event had reconnection but in different frequencies (Table 1)
- Further down events have weaker currents (Figure 4)

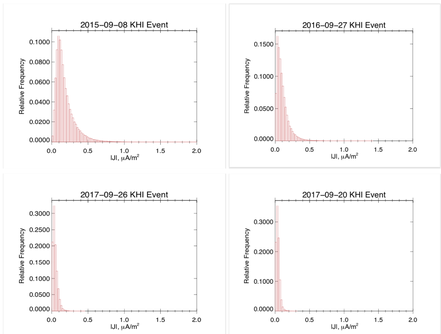

Figure 4, Histograms showing the relative frequencies of different current measurements for each event

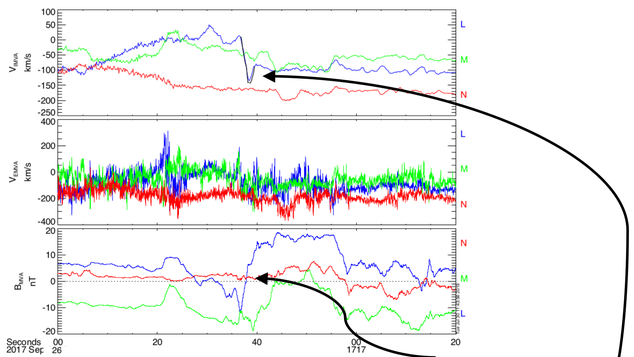

Figure 5, A graph showing a reconnection event. Notice the shift in B_L resulting from MMS passing through antiparallel field lines. This also shows the Walen Test. The black lines are a prediction of the ion velocities assuming that there is reconnection here. Since they fit the data well, we say this is a reconnection event.

4. Conclusions

- There are significantly fewer reconnection jets further down the flank
- Could be explained by the fact that more rolled up KHI has more inflated vortices so everything is on a larger scale
- Means current sheets aren't as thin, which is less ideal for reconnection

Event Date	Candidate Current Sheets	Ion Jets Observed	Jets per Period
9/8/15	42	22	52%
9/27/16	31	5	16.1%
9/26/17	33	4	12.1%
9/20/17	20	1	5%

Table 1, The number of candidate reconnection sites compared to the number of ion jets actually observed

5. Future Work

- Study more events
- Particularly different latitudes

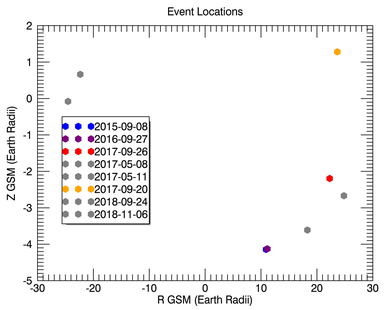

Figure 6, The radii from the Earth and latitudes of the same events

References

1. Nakamura, T. K., Daughton, W., Karimabadi, H., & Eriksson, S. (2013). Three-dimensional dynamics of vortex-induced reconnection and comparison with THEMIS observations. *Journal of Geophysical Research: Space Physics, 118*(9), 5742-5757. doi:10.1002/jgra.50547
2. Eriksson, S., Lavraud, B., Wilder, F. D., Stawarz, J. E., Giles, B. L., Burch, J. L., . . . Goodrich, K. A. (2016). Magnetospheric Multiscale observations of magnetic reconnection associated with Kelvin-Helmholtz waves. *Geophysical Research Letters,43*(11), 5606-5615. doi:10.1002/2016gl068783