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Annales Geophysicae Discussions

Interactive comment on "Plasma transport into the duskside magnetopause caused by Kelvin–Helmholtz vortices in response to the northward turning of the interplanetary magnetic field observed by THEMIS" *by* Guang Qing Yan et al.

Anonymous Referee #1

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The paper reports observations of Kelvin-Helmholtz (KH) vortices by two THEMIS spacecraft (THA and THE) at the dusk magnetopause, dayside of the terminator. The periodic crossings of the magnetopause occurred following a northward turning of the interplanetary magnetic field. The identification of the vortices is based on the computation of boundary normal directions via minimum variance analysis (MVA). Interestingly, low density plasma faster than magnetosheath plasma – a common feature of KH vortices – was not observed. The spacecraft locations allow for an assessment of

the evolution of the vortices: Crossing of regions with mixed magnetospheric and magnetosheath plasmas appear more/less periodic at an earlier/later stage, suggesting the transport of plasma across the magnetopause.

My main criticism is related to the identification of vortices and the interpretation of observations supporting the hypothesis of plasma transport across the magnetopause. At this point, I do not think that the conclusions of the paper are sufficiently supported by the observations.

Specific comments:

1) It is not convincingly shown that the magnetopause oscillations observed are actually due to the passage of magnetopause KH vortices and not, e.g., due to the passage of magnetopause surface waves that have not yet reached the non-linear stage. In this study, vortices are mainly identified by a sequence of boundary normal vectors, obtained from MVA applied to magnetic field observations (e.g., line 122+). However, MVA results can strongly depend on the selected time intervals around current sheets to which the method is applied. It would help enormously if the authors could assess the stability and reliability of the MVA results, also taking into account the eigenvalue ratios as described by Sergeev et al. (Ann. Geophys., 2006). I am doubtful about the reliability of MVA results here, because the magnetic field variations that can be analyzed are not particularly strong (see panels 3 and 7 of Figure 2).

Furthermore, I am concerned about the identification of KH vortices in the absence of low density plasma that is faster than the magnetosheath plasma (e.g., line 141+). This feature has been used to identify vortices using single spacecraft measurements. It may also be observed without vortices being present: the passage of a surface wave should suffice. But if vortices are present, then the feature should be observable too, and I cannot find any statement in Masson and Nykyri (2016) that would suggest the opposite. So the absence of that feature indicates, in my opinion, that the oscillations are rather related to a magnetopause surface wave rather than to KH vortices. Note that rotations in the bulk velocity, magnetic field deviations, and distortions of the magnetopause can also result from magnetopause surface waves (e.g., line 205).

2) It is not convincingly shown that a significant and unambiguous plasma transport took place across the magnetopause (e.g., lines 211, 214). This main conclusion of the paper is inferred from observation of less periodic features seen by THE in comparison to THA, the former being located further down the tail from the latter. I would at least expect some further discussion on how this strong conclusion can be drawn from the observations (e.g., by putting the results into the context of prior observations or simulations). However, also the observations themselves are not consistent over the presented time interval: As can be seen in Figure 2, THA sees more periodic magnetopause oscillations before 22:40 UT, as discussed in the paper. After 22:40, THE sees very periodic oscillations and THA observations are "more dispersed" (e.g., between 22:44 and 22:51). Following the argument in the manuscript, plasmas should have unmixed while vortices moved from THA to THE during this period of time.

3) It is not convincingly shown that there was no pre-existing (low-latitude) boundary layer (LLBL), consisting of a mixture of magnetosheath and magnetospheric plasmas. This mixture is used as a synonym to plasma transport across the magnetopause in the paper (line 164), supposedly starting with the northward turning of the IMF. But a LLBL might have been present at the magnetopause even before the oscillations started. To confirm this or rule it out, we would need spacecraft observations across the magnetopause near the THEMIS positions before the event. However, such observations do not seem to be available, and both THA and THE were probably too far away from the magnetopause to observe a pre-existing LLBL. During the event, as the surface waves went by, the magnetopause moved periodically closer to the spacecraft so that they were able to enter the LLBL, as stated in line 204.

4) I do not know what the authors exactly mean by "field-line stretching" (e.g., lines 22, 118) and how such a behavior would be reflected or identifiable in single spacecraft ion velocity or magnetic field time series.

Minor comments on figures:

- Figure 1 conveys very little information. It may be sufficient to keep only the x-y-plot.

- It may be helpful for the reader to state the meaning of the green and black bars in Figure 2 (below panels 6 and 10) in the caption.

- I cannot see any reason for the inverted time line in Figure 3. Please state a clear reason or display the data in the conventional way, with time moving forward to the right.

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