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Interactive comment on "A source mechanism for magnetotail current sheet flapping" *by* Liisa Juusola et al.

Anonymous Referee #1

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Using the two dimensional global hybrid-Vlasov model Vlasiator, Juusola et al studied the characteristics and source of current sheet flapping in the center of the magnetotail. Their simulations show that an initial down-tail propagating current sheet displacement caused by a hemispherically asymmetric magnetopause perturbation can launch a standing magnetosonic wave within the magnetotail, which acts as a resonance cavity, creating subsequent flapping waves in the current sheet. In three dimensional, Juusola et al suggest that such source mechanism for current sheet flapping could create kink-like waves that had been observed to emit from the center of the tail towards the dawn-dusk flanks. The simulation results from this study could potentially provide explanation on the mechanism for current sheet flapping, which till this day remains unknown, and increase our understanding of the tail flapping phenomenon. However,

much clarification is needed as terminologies are not clearly defined and loosely used. Analysis of results to support their conclusion are lacking, vague and qualitative. In my opinion, major revisions to the manuscript and further clarifications are required.

Comments: 1. Page 1 Line 19: Shouldn't it be "up and down relative to the spacecraft", instead of "back and forth across the spacecraft"? Please clarify.

2. Page 2 Line 9: Insert appropriate reference Sun et al., [2013] THEMIS Observation of a magnetotail current sheet flapping.

3. Page 2 Line 9: In this sentence, the authors categorized current sheet flapping events into three types (Steady, kink-like along y and kink-like along x). To my understanding of this study, Juusola et al focused primarily on the "kink-type along x" current sheet flapping. However, subsequently in the text, the authors used the word current sheet flapping to describe tailward propagating displacement of the current sheet, which I take it to mean "kink-type along x". However, the term current sheet flapping is more commonly described as steady or kink-like along the y-direction in current literature. The authors should clearly state or define what kind of current sheet flapping they are referring to throughout the text so as to not confuse the readers. If at all possible, I would suggest the authors to avoid using tail flapping in this study since many current sheet flapping studies using THEMIS and Cluster data concluded that the current sheet flapping waves travel towards the dawn or dusk flanks (e.g. See review paper by M. Volwerk), which to my understanding from the text, is not what the authors are referring to. This will avoid confusing the readers.

4. Page 3 Line 13: The authors should justify their choice of solar wind parameters in their simulation. A particular set of solar wind conditions, instead of a range of values, are used in this study. This begs the question of how does the solar wind conditions affect the simulation results and conclusion of this study.

5. Page 3 Line 23: I strongly suggest that the authors start section 3 with the simulation results shown in Figure 7. By replacing Figure 1 with Figure 7, it will provide context for

readers who are either not used to or not familiar with simulation studies and improve the flow of the manuscript.

6. Page 5 Line 10: One of the main conclusions of this simulation study was that the “asymmetric perturbation consists of a simultaneous compression of the northern tail lobe and expansion of the southern tail lobe” drives current sheet flapping as shown in their simulation results. However, it is unclear whether this asymmetric perturbation in the simulation is physical or numerical. Furthermore, the authors mentioned that this asymmetric perturbation is caused by subsolar magnetic reconnection (line 8), which is counter-intuitive. Under steady solar wind conditions and dayside reconnection occurring at the subsolar magnetopause region, shouldn’t the loading of the open flux in the two hemisphere of the tail be equal? One might think that unequal loading of open flux in the northern and southern tail lobe is caused by dayside reconnection occurring at higher latitude. Would this implies that the perturbation is a numerical effect? Furthermore, Figure 3 shows that there are regions of high beta around the nightside magnetopause surface. Are there turbulence occurring on the magnetopause surface? Could that been the cause of the asymmetric perturbation? Please clarify.

7. Page 6 Line 9: The use of “cross-tail direction”, which traditionally referred to the y-direction, is very confusing. The simulation is two dimensional in the x and z-direction. Unless the authors meant cross-tail in the z-direction? If that’s the case, the authors should be clear on that as ambiguous use of words could mislead the readers.

8. Page 7 Line 1: In the discussion section, Juusola et al suggested that in three dimensions, the asymmetric perturbation could have a finite extent in the y-direction, thus driving current sheet flapping in the dawn-dusk direction. However, the authors neither substantiate their conclusion with any 3D simulations results nor conduct any experiments that investigate the effects of a finite IMF By on the occurrence and properties of tail flapping waves. Since the authors listed this as one of the five main conclusion of this study, I think substantial work should be done to demonstrate the connection between asymmetric perturbation mechanism and current sheet flapping in the dawn-

dusk direction as observed by earlier studies, rather than simply providing a hand-wavy, qualitative explanation.

9. Page 7 Line 25: Juusola et al stated model predictions for the purpose of future validations with satellite observations. However, the authors did not follow up on this idea of validations with observations, which I think is a wonderful idea. If it is the authors’ intention to validate their simulation results with observations, this study should provide more quantitative results (e.g. what is the relationship between flapping period and lobe pressure? Does it follows a power law or linear relation etc?) and measurable quantities. These information could be easily obtained from the simulation.

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