Helsinki, May 9, 2018

Dear Referee #2,

Thank you for your thorough review of our paper. Below, we go through the points in detail; the original Referee questions are marked with italics.

*Summary: This manuscript examines the physics of magnetosheath jets, using the results of a 5D vlasov simulation of the solar wind – magnetosphere interaction performed using the Vlasiator code. The simulation set up uses steady solar wind conditions, and several magnetosheath jets are reported to occur. The manuscript provides a detailed analysis of one jet in particular that is relatively large, and examines how three different identification criteria, previously published, capture the structure. The size of the jet is quantified, and is found to be consistent with experimental observations. Finally, the magnetosheath jet is shown to be associated with a variation in the upstream pressure that is caused by foreshock waves. The work provides a useful counterpoint to observational studies by showing for the first time that the different signatures adopted in different studies can in fact identify the same event, and therefore help to unify understanding of what these structures are. It also provides a global view of the phenomenon, and contact is made with observations by estimating the size of the jet.*

*Overall, my primary concern with the manuscript is that it does not do full justice to what is a very interesting and important simulation result. It is important to compare the three identification criteria, but I think there is more that should be done. This relates to the physics questions about how the jets are formed and their impact on the magnetopause, which will be of wider interest. I would be unwilling to recommend the manuscript for publication without addressing the following two points:*

*1) There is some limited discussion about the source of the magnetosheath jet, but the Vlasiator data surely allows for a much more detailed examination of the proposed formation mechanism and the nature of the ULF waves. In particular, it should be possible to generate some virtual spacecraft data for the upstream ULF waves (e.g. placed just upstream of the shock from where the jet arises) and see immediately if it is the formation of a SLAMS that happens here. Showing and discussing the data would significantly strengthen the manuscript. Similarly, how does the profile of the shock change as the ULF wave pressure front arrives and the jet begins to penetrate into the magnetosheath? Providing more information about the formation mechanism would significantly strengthen the paper and I think it would not be too difficult to extract this information.*

We fully agree with the Reviewer, and note that also the other Reviewer made this same point. This is indeed easy to add to the manuscript, and should this manuscript be accepted for revision, we shall carry out a detailed examination of the structure that causes our jet, along the lines that the Reviewer suggested.

*2) I was surprised that there is no discussion about the impact of the jet on the magnetopause. In supplementary movie 1, at around t = 325 – 340 s, there is an oscillation of the magnetopause at x = 7.5, y = -4 (very roughly) which seems to follow directly from the arrival of the remnant of the jet. Two pulses traveling away from the impact point along the magnetopause are visible, and I wonder if this is reconnection triggered by the jet. Again I think it would significantly strengthen the paper to add information about the fate of the jet and its impact on the magnetopause.*

Again, the Reviewer is absolutely right. We omitted this discussion because we tend to avoid making conclusions at the magnetopause due to the pileup effect (see our answer to the other Reviewer, point #3). We agree with the Reviewer and think that the magnetopause oscillation is

caused by the jet. We shall add this information and a related analysis to the manuscript, along with a proper discussion about the pileup effect.

*3) Evolution of the jet size. The jet size is quoted for one particular time, but it would be very good to provide more information about how the jet size changes. In particular, does the length parallel to the flow change more than the length perpendicular? This should be possible to extract from the simulation as well.*

Should the Editor accept this manuscript for revision, we shall add this information into the manuscript.

*4) Jet occurrence. Watching the movies in the supplementary information, it seems that other jets do occur. Given the fact that the simulation is scaled to the Earth, is it possible to say anything about the occurrence rate and if this is consistent with observations?*

Yes, indeed it is. However, we chose not to do this in this manuscript. This is because we would first like a proof-of-concept paper, where we verify the methodology, so that we can trust the results. Once this has been carried out, we can adopt the methodology to all our runs, to all our jets, leading to possibly (tens of) thousands of observation points in space and time, given that we have now several runs with varying conditions that can be used. It would be impractical to verify this many jets in this detail in practice, and therefore we thought it is good to verify one first.

*5) Change in jet profile. It would be very useful from a spacecraft observation point of view to know how the profile of the jet - as would be observed by the spacecraft – changes with distance from the shock. Again this is something that Vlasiator would be able to show more clearly, and would be able to be extracted from the data.*

This is an excellent suggestion. Both the Karlsson, and Archer and Horbury criteria are determined from the peak values, and the full-width-at-half-maximum approximation when analyzing the spatial scales. What indeed we could do, and we thank the Reviewer for pointing this out, is an evolution of the full-width-at-half-maximum parameter in time and space. We shall add this, if the Editor asks for a revision

Thank you again for your very helpful and constructive comments, which will significantly increase the quality of the manuscript, we appreciate the time you spent on our work.

On behalf of all the co-authors,
Minna Palmroth