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Interactive comment

Interactive comment on "Magnetosheath jet evolution as a function of lifetime: Global hybrid-Vlasov simulations compared to MMS observations" *by* Minna Palmroth et al.

Anonymous Referee #2

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The paper by Palmroth et al. discusses results obtained by four runs of a 2D3V hybrid Vlasov code, where the ions are treated kinetically and the electrons as a massless fluid. The manuscript focuses on results of simulations from four sets of initial conditions assumed for the upstream solar wind.

There are two major limitations of these simulations: the kinetic treatment is truncated (the kinetic physics of electrons is disregarded) and the plasma macroscopic dynamics is reduced to two spatial dimensions, in the equatorial plane. Can the authors discuss these limitations and demonstrate that the numerical simulations based on such a truncated description of plasma dynamics still captures accurately the physics of

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Discussion paper

jets as observed in the magnetosheath (see, e.g., the analysis of the jet anatomy by Karlsson et al, 2018)?

The usefulness of the comparison between a statistical analysis of simulations and MMS observations of jets (collected over almost four years) is not clear to me. The authors state that MMS data serve to “verify the simulation behavior”, thus, they aim to validate the hybrid Vlasov simulations with MMS data. However, there is no indication on the upstream solar wind conditions for the 6142 jets detected by MMS1. On the other hand, the statistical ensemble of 924 jets observed in hybrid Vlasov simulations is generated by only four sets of solar wind parameters (magnetic field, density, bulk velocity, cone angle and Mach number), as shown in Table 1. Therefore I am wondering how could one relate, compare and validate simulations of the magnetosheath jets as resulting from these four sets of solar wind parameters with the observations of magnetosheath jets corresponding to 6142 MMS events, and therefore for a much larger set of solar wind conditions ? The authors do show that MMS observations for one jet (figure 2) correspond to a solar wind velocity “around 410 kms−1, density about 3.8 particles per cubic centimetre, the magnetic field vector about [−4, 3, −2] nT, and MA is 7” relatively close to the initial conditions assumed for the simulations reported in case LM30. However, even for this case there are significant differences in terms of jet characteristics, as outlined by the authors: “The velocity and the magnetic field show some discrepancies, such as slower flows and more variable magnetic fields at MMS, reflecting the differences in the solar wind conditions as well as the different relative positions within the magnetosheath. [...] Similarly, the differences in the density and temperature can be understood in terms of the differences in the solar wind parameters”. Although in Figure 5 is suggested a normalization with respect to solar wind parameters, it is not clear where the solar wind parameters are derived from in case of MMS data.

The supplementary video material raises additional questions. The magnetosheath can be roughly identified in this movie as the spatial region between (an imaginary) magnetopause (as in Figure 3 of the manuscript – the Shue model) and the red line (the bow-shock). (The authors point out the magnetopause cannot be easily identified in their simulations). It looks like the dynamical pressure irregularities do not follow the general streaming or the magnetosheath flow as they seem to be predominantly convected in the duskward direction, which is puzzling. From the general gasdynamics of a supersonic flow around an obstacle one would expect a stagnation point in the nose region and azymuthal flows, duskward and dawnward, at the two flanks. Also, one notes that some jets (identified by red dots) apparently occur spontaneously at significant distances from the bow-shock, in the magnetosheath, where they spend some time and then disappear ("die") (e.g. the sequence between t=551 and t=557 seconds, roughly at X=12, Y=1). I am not sure this behavior really captures the dynamics of magnetosheath jets which are believed to be structures born at the bow-shock (e.g., Karlsson et al., 2018). When watching the movie in the supplementary material I am wondering if some of the structures considered in this study are not in fact local magnetosheath fluctuations (some of them related perhaps to the inherent numerical simulation noise and/or truncated physics) and not jets, as they are defined in the literature.

The statistical analysis of simulations results is interesting. However, given the complexity of this type of numerical simulations, the authors should give more evidence on how the results depend on the numerical setup and noise. I assume such tests were extensively performed and the authors should discuss if and how the results depend on the spatial and velocity resolution, as well as the time step assumed for the simulations. This is important for understanding the results of the statistical analysis.

The jet size distribution, as revealed by Figures 7 and 8, indicates that the structures studied with the hybrid Vlasov simulations are rather small scale and short lived, with most probable sizes of the order of hundred of kilometers and most probable lifetimes of the order of seconds. While lifetimes were not yet investigated with in-situ data, scale sizes derived from observations (e.g. Plaschke et al, 2016) are orders of magnitude larger, as noted by the authors themselves. This difference leads me back to the remark I made in the previous paragraph: are the structures studied in this report magnetosheath jets or local non-homogeneities downstream the bow-shock, and satisfying the selection criteria based on the dynamic pressure excess (Eq. 1) ?

Finally, I have a question for the authors. This manuscript, and many others dedicated to magnetosheath jets, presents statistics of various parameters of jets in order to describe their properties. Thus, it is implicitly recognized that these jets are plasma structures to which we can assign a shape, a size, a bulk velocity, a temperature, a lifetime. My question for the authors is which is, in their opinion, the physical process that grants the jets their individual identity, allowing them to have an individual dynamics, apparently different/independent than/from the background magnetosheath.

I see an issue with the availability of simulations and MMS data on which the findings of this manuscript are based. I am wondering if there is compliance with Annales Geophsycae policy on data availability. Indeed, the authors indicate Acknowledgments that “Data presented in this paper can be accessed by following the data policy on the Vlasiator web site.” On the Vlasiator website I found the following statement regarding simulations data availability: “All data requests and other support questions should be addressed to the PI. The PI-team decides about the time and place in which the peer-reviewed data becomes public.” I think the authors should demonstrate the simulations and experimental data are available from a public data repository as requested by Annales Geophysicae data policy (https://www.annales-geophysicae.net/about/data_policy.html), I quote : “It is particularly important that data and other information underpinning the research findings are "findable, accessible, interoperable, and reusable" (FAIR) not only for humans but also for machines. Therefore, Copernicus Publications requests depositing data that correspond to journal articles in reliable (public) data repositories, assigning digital object identifiers, and properly citing data sets as individual contributions. [...] A data citation in a publication resembles a bibliographic citation and needs to be included in the publication’s reference list. [...] In addition, data sets, model code, video supplements, video abstracts, International Geo Sample Numbers, and other digital assets should be linked to the article through DOIs in the assets tab."

Minor remark: Section 2.2. consists on a single paragraph. I suggest the authors expand it and include a description of the MMS data used in their study or integrate the paragraph in the previous section.

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