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Discussions

Interactive comment on "Magnetosheath jet properties and evolution as determined by a global hybrid-Vlasov simulation" *by* Minna Palmroth et al.

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I have just missed the deadline of short comments for the "Blanco-Cano et al., Cavitons and spontaneous hot flow anomalies in a hybrid-Vlasov global magnetospheric simulation" manuscript. The authors of this paper are almost similar to the SHFA related paper hence I leave my comments here. Sorry for the mess.

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This is a very nice paper about the development of the foreshock cavitons and magnetosheath cavities based on unique real size global hybrid-Vlasov simulations. However, the simulation accuracy is questionable and the simulation results cannot reproduce the main features of the spontaneous hot flow anomalies (SHFA): the "shoulders" of

the cavity (the shocks around the SHFA) and the considerable drop of the SHFA. (The latter feature gave the name of the phenomenon!!!)

I would like to help the authors to prepare the next version of the manuscript. Hence I give my main concerns and comments below:

Title: I suggest using "Temporal development of foreshock cavitons in a hybrid-Vlasov global magnetospheric simulation". These phenomena are not SHFAs at all.

Page 2, Line 19-20: "[. . .] hot flow anomalies (HFAs) (Schwartz et al., 1985; Schwartz, 1995), [. . .]"

Facsko et al. (2010) wrote a review paper about HFAs. It would be appropriate to add to the list.

Page 2, Line 35: "The formation of an HFA needs an external perturbation in the solar wind, e.g., a current sheet interacting with a bow shock."

Actually the current sheet must be oriented appropriately and there are conditions for the rotation of the magnetic field in the discontinuity (Schwartz et al., 2000; Facsko et al., 2008, 2009, 2010). Both HFAs and SHFAs prefer high solar wind speed conditions (Safrankova et al., 2002; Facsko et al. 2008, 2009, 2010)

Safrankova, J. et al., The structure of hot flow anomalies in the magnetosheath, Advances in Space Research, Volume 30, pages 2737-2744, 2002

Schwartz, S. J. et al., Conditions for the formation of hot flow anomalies at Earth's bow shock, Journal of Geophysical Research, Volume 105, pages 12639-12650, doi: 10.1029/1999JA000320, 2000

Page 3, Line 5: "The proposed formation mechanism for SHFAs includes multiple ion reflections between foreshock cavitons and the bow shock (Omidi et al., 2013), as cavitons approach the shock, and ion trapping occurs in the cavitons."

Similar mechanism heats the HFAs too. However, the convective electric field focuses and leads back the accelerated and back-scattered ions to the bow shock.

Page 3, Line 13-15: "As a consequence of ULF waves, shocklets and SLAMS merging into the shock, the quasi-parallel portion of the bow shock is far from being a single well defined surface, but instead forms a highly corrugated/rippled extended structure, where inhomogeneous heating and solar wind processing can take place (see, for example, Schwartz and Burgess, 15 1991; Omidi et al., 2005; Blanco-Cano et al., 2009)."

. . . and very strong acceleration processes as well (Wilson et al., 2016).

Wilson, L. B. et al., Relativistic Electrons Produced by Foreshock Disturbances Observed Upstream of Earth's Bow Shock, Physical Review Letters, Vol. 117, No. 21, doi:10.1103/PhysRevLett.117.215101, 2016

Page 4, Line 19-24: These are not typical solar wind parameters and not typical parameters for HFA/SHFA formation. Why did you choose such high solar wind speed? Why is the solar wind density so low? (Lower solar wind density is normal at HFA formation according to Facsko et al. (2009), Figure 11a). What are the components of the IMF? Do you have a Bx component?

The simulation time is quite short. The inbound solar wind at T=0s reaches ∼166 RE until the end of the simulation. Is it enough for reaching a quasi-stationary state? How did you do the initialisation of the simulation? Could you please present the video of the full simulation domain?

Page 5, Line 33-34: "SHFAs are also characterized by decrements in density and magnetic field strength, but have in addition a higher temperature than the surrounding plasma."

And the surrounding shock and the huge solar wind velocity depletion. These features cannot be neglected.

Page 5, Line 34-Page 7, Line 1: "However, setting a criterion on the temperature is

not straightforward since SHFAs are immersed in the foreshock, which has a higher temperature than the pristine solar wind."

Where have you observed several 10 MK temperature in the foreshock?

Page 7, Line 1-3: "[. . .] deviations from the bulk solar wind velocity are observed throughout the foreshock, and they are not prominent enough inside SHFAs to be unambiguously identified."

Those phenomena that do not show anomalous flow cannot be called Spontaneous Hot FLOW ANOMALY. (And neither are they HOT.)

Page 6, Figure 1: Could you please provide an image of the full simulation domain with the same colours and scale? Has the VLASIATOR simulation reached a quasi-stationary state?

Page 7, Line 3-6: Provide a reference for this method or prove that it is applicable here.

Page 7, Line 13-14: "In a 3-D run, the total number of these structures in the whole foreshock would most likely be larger."

Why?

Page 8, Line 3-31: Where is the cavity?

Page 8, Line 33-34: "The shaded areas in Figure 3 show how at time T2 there are multiple large cavitons upstream of the shock. SHFAs are found at shaded areas where also beta > 10."

I see neither SHFA/cavity nor velocity depletion on Figure 3. This event cannot be a SHFA.

Page 10, Figure 3: I do not see any SHFA here. The density and the magnetic field should drop significantly. The temperature should reach several 10 MK. The solar wind flow should drop significantly.

Page 10, Line 1-2: “In the sixth panel, small dips in the value of |V| associated with cavitons and SHFAs can also be identified.”

I cannot see any dips, only the bow shock transition is visible. Actually the solar wind speed should drop significantly, a few 100 km/s.

Page 12, Line 26/27: “Position C is located within an upstream SHFA [. . .]”

Page 14, Figure 6c, h, n: The (S)HFAs are formed by the interaction of the solar wind ions and the reflected and accelerated ion beam of the bow shock. In young (S)HFAs the two populations can be distinguished by the ion velocity distributions at Vx=0 km/s and Vx=600 km/s. (Lucek et al, 2004, Figure 4b; Zhang et al., 2010, Figure 7b). These events must be young (at least C). I cannot see the typical distribution with double peak. Hence these structures are not SHFAs or they aged very quickly. (The mature (S)HFAs have no such velocity distributions.)

Page 16, Figure 7: See comments for Figure 3.

Page 17, Line 26: “We suggest that suprathermal beam ion PADs are a useful tool for identifying SHFAs in the foreshock.”

. . . according to Kecskemety et al. (2006).

Page 18, Figure 8: The distribution of the relative amount (count/total count) would be compared easier.

Page 20, Figure 9: The drop of the density and magnetic field is not sufficient. The depth of the drop neither. The temperature should reach several million K even in a SHFA. I cannot see any velocity drop here.

Page 20, Line 14-15: “This may also explain why the caviton shown in Fig. 9 does not display the "shoulders" of enhanced plasma density identified in spacecraft observations on either sides of the density and magnetic field depression.”

These “shoulders”, the shocks are very important features of the SHFAs. Their pres-

ence proves that the cavity is not in equilibrium and expands. If the VLASIATOR cannot create them that is big a problem. The hybrid simulations of Nick Omidi and Yu Lin could present these shoulders. What is the advantage of using VLASIATOR if the hybrid-Vlasov code cannot present these shocks? Furthermore, these shocks lead to the observed depletion of the solar wind velocity because the deceleration of the solar wind comes from the bad fitting and plasma moment calculation (Kecskemety et al., 2006, Figure 3 and 7; Parks et al., 2013).

Page 22, Line 19-20: “That is, the flow of the thermal solar wind core was not slowed or deflected, but rather, changes in bulk flow are due to the combination of a density decrease for the core and a strengthening of the suprathermal beam. When the thermal core is depleted, the backstreaming beam can have a relatively greater impact on bulk velocity measurements.”

In this case the decrease of the velocity would be deeper. See my comments above, the lack of “shoulders” in density and magnetic field is related to the missing velocity decrease. This is an important feature that cannot be neglected. If these features are missing, the phenomena are not SHFA or the VLASIATOR needs further improvement to be able to study them.

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