Comments on "Cavitons and spontaneous hot flow anomalies in a hybrid-Vlasov global magnetospheric simulation" by Blanco-Cano et al. (2018)

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Blanco-Cano et al. (2018) analysed the output of the VLASIATOR global hybrid Vlasov solver and intended to find Spontaneous Hot Flow Anomalies (SHFA, Zhang et al., 2013; Omidi et al., 2013). This is a very nice paper about the development of the foreshock cavitons and magnetosheath cavities based on unique global hybrid-Vlasov simulations. However, the simulation results cannot reproduce the main features of the SHFAs. The SHFAs (and the HFAs) show density and magnetic field magnitude drops in their cavity. The magnetic field is turbulent in the cavity ~~and shocks form on both sides of the event~~. The temperature is very high in them, a few million K. The solar wind direction turns away from the radial direction and slows down (Facskó et al., 2010; Zhang et al., 2013; Omidi et al., 2013). The latter features gave the name of the phenomenon hence I had serious concerns about whether the Authors had detected SHFA in the paper above.

On Figure 3, 7, 9 of the paper above, the Authors see density and magnetic field drops. ~~I can see no drop in either the density or magnetic field magnitude. Hence this event cannot be an SHFA or even a foreshock cavity.~~ The simulated phenomena is not significantly hotter than the surrounding foreshock plasma. The foreshock plasma temperature is never observed at 10 million K. Hence locating in the foreshock cannot be an excuse for the missing feature of the phenomena. The Authors also see "*[. . .] deviations from the bulk solar wind velocity are observed throughout the foreshock, and they are not prominent enough inside SHFAs to be unambiguously identified.*" The phenomenon that does not show anomalous flow cannot be called Spontaneous Hot Flow Anomaly.

~~Unfortunately, not only the physical indicators are missing from the simulation result, but the footprints and the signs of the SHFA formation processes too. The (S)HFAs are formed by the interaction of the solar wind ions with 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 $V_x = 0 km/s$ and $V_x = 600 km/s$ (see Figure 4b in~~ Lucek et al. (2004) ~~and Figure 7b in~~ Zhang et al. (2010)~~). The c, h and n events on Figure 6 must be young (at least c; as the mature (S)HFAs have no such velocity distributions). I cannot see the typical distribution with double peak. Hence, these structures are not SHFAs.~~

The SHFAs are surrounded by ~~shocks~~ **density and magnetic field increase at the edge of the phenomena**. Their presence 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 Omidi et al. (2013) could present these shoulders (Lin (2002) could also have simulated them for HFAs). Furthermore, these ~~shocks~~ **increases** 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 (Parks et al., 2013; Kecskeméty et al., 2006, Figure 3, 7). Hence, it is possible to explain the missing solar wind deceleration if these ~~shocks~~ **increasements** are present. If both features are missing, the phenomena cannot be SHFA ~~or the VLASIATOR needs further improvement to be able to study them~~.

The Authors also study foreshock cavitons, magnetosheath filaments and structures in this paper above. My comments are limited only to the identification and analysis of the "SHFA events" of the simulation. Based on the remarks described above, I am sure that the features in the VLASIATOR simulations are not SHFAs. **However, these questionable events could develop to an SHFA. Zhang et al. (2013) observed SHFA–like events without significant solar wind deceleration. As Zhang et al. (2010) discovered and introduced the phenomenon of so called proto-HFA, Zhang et al. (2013) discovered the phenomena of proto-SHFA. These proto-SHFAs were simulated by the VLASIATOR code and misinterpreted by the Authors.**

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Response on "Interactive comment on "Comments on "Cavitons and spontaneous hot flow anomalies in a hybrid-Vlasov global magnetospheric simulation"by Blanco-Cano et al. (2018)" by Gábor Facskó" by Andrey Samsonov

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1 Comments from Referee

I agree with most of the comments from the referee. I list here only those statements with which I do not perfectly agree:

1. *Facsko (2019) also notes that the ion distribution function in Figure 6 does not match the one which is expected for SHFAs. Comparing Figure 6 and Figure 3g in Zhang et al. (2013), I cannot be so categorical. A typical SHFA in Figure 3g clearly shows the main earthward solar wind core and the reflected beam propagating sunward. The distribution function in Figure 6 does not demonstrate the reflected beam so definitely, however it still displays similar properties and the local maximum is located in the position determined by the IMF orientation. In my opinion, it is not necessary to be at* $V_x = 0\,km/s$ *and* $V_x = 600\,km/s$ *as stated by Facsko (2019).*

2. *I do not agree with another statement in Facsko (2019) that the SHFAs are always surrounded by shocks. The density and magnetic field magnitude increase at the edges of SHFA, but they are not necessarily to be shocks (shocks must satisfy the certain conditions on the velocity). The SHFAs presented in Zhang et al. (2013) and in Figure 11 in Kajdic et al. (2017) are not surrounded by the shocks*

2 Author's response

The author would like to thank the Referee for the helpful and constructive comments and suggestions which helped to improve the manuscript.

1. The peaks are not always at 0 and 600 km/s. However there are two maxima in the young HFAs at the solar wind and the reflected particle populations. The velocity distribution functions in Figure 6 are not convincing at all. For HFAs the

electron energy spectra would help to decide whether the event is young or mature Wang et al. (2013). However, it is not possible when you are using a hybrid plasma simulation where the electrons are neutralising fluid. The wave activity in the HFA cavity could also help to decide the age of the events Tjulin et al. (2008). However, nobody has studied the wave activity in the cavitiy of SHFAs. Hence, we have only Figure 6, and the double peaks are very faint there.

2. The SHFAs are not surrounded by shocks. However, at the edge of the phenomena the density and the magnetic field are increased. However, they should be observed as consequence of the expansion. These moving increases disturb the normal way of plasma momentum calculation and hence cause the anomalous flow (Kecskeméty et al., 2006; Parks et al., 2013).

The final conclusion is that the simulated phenomena were not SHFAs. However, the events could have developed into SHFA. These objects are so–called proto-SHFA, which is another cathegory of the transient events.

3 Author's changes in manuscript

Line 6 The "*and shocks form on both sides of the event*" text was deleted.

Line 10–11 The "*I can see no drop in either the den- sity or magnetic field magnitude. Hence this event cannot be an SHFA or even a foreshock cavity.*" sentence was deleted.

Line 16 Underline deleted.

Line 17–22 The "*Unfortunately, not only the physical indicators are missing from the simulation result, but the footprints and the signs of the SHFA formation processes too. The (S)HFAs are formed by the interaction of the solar wind ions with 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* $V_x = 0\,km/s$ *and* $V_x = 600\,km/s$ *(see Figure 4b in Lucek et al. (2004) and Figure 7b in Zhang et al. (2010)). The c, h and n events on Figure 6 must be young (at least c; as the mature (S)HFAs have no such velocity distributions). I cannot see the typical distribution with double peak. Hence, these structures are not SHFAs.*" paragraph was deleted.

Line 23 The sentence was modified: "*shocks*" → "*density and magnetic field increasement at the edge of the phenomena*".

Line 24 The "*If the VLASIATOR cannot create them, that is big a problem.*" sentence was deleted.

Line 26 A word was modified: "*shocks*" → "*increases*".

Line 28 A word was modified: "*shocks*" → "*increases*".

Line 29–30 The "*or the VLASIATOR needs further improvement to be able to study them.*" sentence was deleted.

Line 34–37 The paragraph was extended: "*However, these questionable events could develop into an SHFA. Zhang et al. (2013) observed SHFA–like events without significant solar wind deceleration. As Zhang et al. (2010) discovered and instroduced the phenomenon of so called proto-HFA, Zhang et al. (2013) discovered the phenomena of proto-SHFA. These proto-SHFAs were simulated by the VLASIATOR code and misintepreted by the Authors.*"

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