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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

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Blanco-Cano et al. (2018) presented results of the global magnetospheric hybrid-Vlasov code and concluded that their model reproduces the formation of foreshock cavitons and spontaneous hot flow anomalies (SHFAs). However, Facsko (2019) argues that their results cannot be interpreted as SHFAs. He points out several features of SHFAs which are not reproduced in the numerical simulations of Blanco-Cano et al. (2019). As shown below, I agree only with some of the arguments in Facsko (2019). Let us begin with the terminology. Both foreshock cavitons and SHFAs occur upstream of the quasi-parallel bow shock, but they have different properties. Foreshock cavitons mean significant decrease in the density and magnetic field magnitude in the core and increase in these two parameters at the edges of the structure. At the same time, both the solar wind velocity and temperature do not change significantly through the cavitons (Kajdič et al., 2013, 2017). On the contrary, the main properties of SHFA are supposed to be (1) a significant increase of the solar wind temperature and (2) deceleration and diversion of the solar wind stream. In particular, Omidi et al. (2013) in their hybrid simulation obtained that the ion temperature is over 600 times hotter than the pristine solar wind and the Vx velocity may occasionally change the sign and become sunward directed. However, the observation of SHFA in Zhang et al. (2013) shows only four (or ten) times increase in the temperature, but still significant variations in the velocity. Finally, the statistical results in Kajdič et al. (2017) display an average decrease in the solar wind velocity by $\sim 40\%$.

Blanco-Cano et al. (2018) identified as cavitons those structures where the density and magnetic field magnitude are less than 80$\%$ of the corresponding parameters in the pristine solar wind, and they used a threshold of β>10 to pinpoint SHFAs. In the solar wind input condition β=0.7, i.e. the threshold gives a 14-times increase. The plasma beta is the ratio of the thermal pressure to the magnetic pressure, $\beta = (2\mu_0 n k_B T)/B^2$. The variations in β are not identical to the variations in T, but may be a good indicator unless the magnetic field magnitude B does not significantly decrease. Figures 3 and 7 in Blanco-Cano et al. (2018) present spatial profiles through the bow shock and foreshock, and Figure 9 displays time series of virtual spacecraft data in the foreshock. According to Figures 2 and 5, cuts 1-2 in Figure 3 and cut 1 in Figure 7 cross several SHFAs. The model predicts a peak in the ion temperature Tp=13 MK at x=∼6.4 RE (cut 1) in Figure 3, and this is significantly larger than the solar wind temperature Tp=0.5 MK. However, this peak does not match any significant change in the velocity. It is located close to the foot of the bow shock. Another candidate for SHFA is at x=2.9 RE (cut 1) in Figure 7. Again, the ion temperature grows up to nearly 8 MK. In this case, it coincides with a bulk velocity decrease (only about 10$\%$). But since this variation is at the foot of the bow shock, it might be associated with the internal bow shock structure.

Finally, the time series in Figure 9 show a peak in the temperature at t=∼1080 s, but Blanco-Cano et al. noted that this structure is only a caviton "evolving towards an SHFA".

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 Vx=0 km/s and Vx=600 km/s as stated by Facsko (2019).

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 Kajdič et al. (2017) are not surrounded by the shocks.

Summarizing this review, I note that the study of SHFAs began only recently (the term itself was introduced in Zhang et al. and Omidi et al.). SHFAs were simulated in the hybrid simulations in several papers by Omidi et al. (a sunward plasma flow was also obtained in the kinetic simulation of Karimabadi et al., 2014), and several papers presented SHFA observations. I would not be very categorical when specifying the SHFA properties. I repeat that the main SHFA features seem to be increase in the temperature and decrease in the velocity. As noted above, the simulation in Blanco-Cano et al. reproduces increase in the temperature (at least in two cases), but predicts insignificant changes in the velocity. Blanco-Cano et al. discuss this issue in the paper (1st paragraph in p. 1094). They compare the distribution function obtained in the simulation and the one observed by Zhang et al. and concluded that both have a similar structure. I would add that Zhang et al. (2013) also presented three events of proto-SHFAs with small variations in the velocity. They assumed that the proto-SHFAs may later evolve into mature SHFAs. This may be the case in Blanco-Cano et al.'s simulation too, i.e. a prolongation of the computation time probably could give results with more distinctive SHFA features. The solar wind velocity in the simulation is significantly larger than the typical solar wind speed, and the structures (cavitons, SHFAs) may convect quickly along the bow shock (Blanco-Cano et al. also noted this point).

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