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Interactive comment on "Helium in the Earth's foreshock: a global Vlasiator survey" *by* Markus Battarbee et al.

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The submitted work investigates the helium foreshock in simulation and MMS/HPCA observation. (Throughout, all mentioned helium is doubly ionized.)

The main simulation of interest is 2D3V hybrid-Vlasov ions and massless-fluid electrons, with setup very similar to previously published work - low-β fast solar wind, 45° cone-angle, supercritical. This is as appropriate for the study as is feasible, but I must wonder what acts in place of electron pressure gradients for the cross-shock potential. I suspect/guess (cf. I think Gosling+ 82, "Evidence for spec. refl. ions upstr. from the Q|| bow shock", and Gosling + 89, "Ion refl. and downstream thermalization at the Q|| bow shock", it's been a while) that some deviation from the specular reflection ovals should

be expected if the main shock ramp jump is smaller or less sharp, in particular - this is possibly a shortcoming of the reviewer, but some demonstration of the cross-shock potential at an interesting point or two would have been nice to see...

The data used are appropriate for the study (although more could have been gotten out of burst HPCA data as in the cited HPCA papers). However it's not clear if the figures couldn't be better labeled - Figures 3's caption is traveling backwards in time. Further, the suprathermal proton and helium population seem to go above HPCA's energy range on 30 Dec 2018 so perhaps some kind of either Maxwellian or κ fit to averaged foreshock E/Z slice would increase confidence that the suprathermals were being counted far enough up. This issue and the different suprathermal definitions (which could be explained in the text for those not fluent in Vlasiator nuances) seem to make comparison harder than necessary.

The analysis lost me a bit right around the very large $T_{||}/T_{\perp}$ — could the resolution be hindering something like firehose growth that would bring that down? This could be an issue; checking Gary's microinstabilities book (7.2.1 and fig. 7.1) and assuming β sane, I'd guess that you could be missing some physics there. I think that given the nature of the work this is to be expected, but it could be mentioned for completion's sake.

Having picked those nits I think this work should be published after some minor-to-moderate complaints are addressed. In general there are some Vlasiator-specific nuances that are not common enough knowledge (at least for this reviewer) and possibly could be made so without detracting from the simulations section.

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