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Interactive comment on "A deep insight into the Ion Foreshock with the help of Test-particles Two-dimensional simulations" *by* Philippe Savoini and Bertrand Lembege

Yann Pfau-Kempf (Referee)

yann.kempf@helsinki.fi

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General comments

"A deep insight into the Ion Foreshock with the help of Test-particles Two-dimensional simulations" by Philippe Savoini and Bertrand Lembège presents a detailed analysis of 2D test-particle simulations of the ion foreshock. The simulations are tailored towards clarifying the role of various electric field components and the shock dynamics in the formation of the previously-reported field-aligned beam (FAB) and gyrophase-bunched (GPB) foreshock ion populations. Overall the study is well constructed but the manuscript would greatly benefit from a range of clarifications. I have a series of

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comments I would like to see discussed/addressed by the authors, as well as a number of suggestions for technical corrections listed below.

Specific comments

- Lines 22-24: More recent terrestrial foreshock studies could be cited too, but I leave it to the authors to decide as this does certainly not need to be exhaustive. Examples are Strumik et al 2015 (10.1002/2015GL064915); Liu et al 2017 (10.1002/2017JA024480); Otsuka et al 2018 (10.3847/1538-4357/aaa23f); Gutynska et al 2019 (10.1029/2019JA026970); Urbář et al 2019 (10.1029/2019JA026734); Turc et al 2019 (10.1029/2019GL084437). I would also like to draw the attention of the authors to the recent paper by Battarbee et al 2020 (10.5194/angeo-2019-115) which studies ion reflection at the non-stationary terrestrial bow shock, albeit in the quasi-parallel region.

- Lines 73-74 and further: It is unclear from reading this manuscript how the electric field component split is performed and which terms in the equations exactly correspond to El and Et respectively. With respect to what are "transverse" and "longitudinal" defined? I assume this would be the magnetic field but then I am confused in particular by the occurrence of parallel electric field (l. 209) and even El// (l. 236). Even though this has been treated in previous articles I would appreciate if these key elements were introduced here as well as the definition of the various electric field components is a critical piece of information for this study. I am also confused by the notations: is there a difference between components noted with a tilde, an arrow and without?

- The nomenclature regarding Fermi processes is confusing and could be made consistent throughout. Or, if different processes are meant, then they should be introduced in more detail.

- I suggest to add "shock" to "front" on line 57 to avoid potential confusion with the fields in front/upstream of the shock.

- Figures 1, 2 and 11: I would suggest to show the in-plane IMF direction and mention the out-of-plane component of the IMF for clarity.

- Lines 63-64: Section 2 also describes the test-particle simulations. Sections 3-6 exist in the current version so this paragraph should be updated.

- End of section 2.1: The system size, spatial resolution and scalings are pieces of information that would be useful, in particular since they are being referred to, e.g. line 118 or Figure 9.

- Section 2.2: I would also suggest to order the HE and FCE consistently throughout (abstract, introduction, figure 1, section 2.2, sections 3 and 4), maybe indeed taking first FCE and then HE every time.

- Lines 109-110: Is v_thi averaged over the box?

- Figure 2 and lines 111-112: The particles are colour-coded differently in the rest of the manuscript so this mention of the colouring of particles is incorrect.

- End of section 2.2. The description of the HE procedure is unclear to me. - Where is the origin of the transformation? Are only shock points transformed or everything outside of the origin? Are the resulting fields then interpolated back to the original resolution or is the grid resolution expanding as well? - Lines 131-132: "Then, each front profile is selected within a same simulation time range DT..." What does this mean? Is DT $\sim$ 4 the difference between 5.4 and 1.2 cyclotron times and there is 174 "snapshots" taken to propagate 1 million particles each? Section 4 mentions 100 runs, also, so I guess that only the more interesting last 100 are taken? - Reading Section 4 lines 284-289 I understand better. So that paragraph and the one in section 2.2 should maybe be joined with an effort to clarify the scheme. - How long are the HE and FCE runs? - When are the test particles released in the FCE case? At a single time or over a certain period?

- Figure 3 and 6b: Is the colour code a density? What are the units? "Spatial distribution

of percentage" is rather imprecise. It would also help the comparison if all panels were on the same colour scale, maybe with a logarithmic colour scale overall as Box 1 is very different.

- Figure 4 and discussion in the text from line 164 onwards: What is the definition of the shock position in this study? As shown by Battarbee et al 2020 (10.5194/angeo-2019-115), Figure 2 in particular, depending on the criterion taken the "position" of the shock can vary dramatically.

- Figure 5: It might help the comparison if all plots had the same y axis, maybe with a logarithmic scale?

- Figure 8: It might help the comparison if all plots had the same y axis. Line 258 and the figure: are the blue lines linear fits or drawn "by hand" to illustrate?

- Line 261: How are the particles released at the same distance if they were released within the boxes of Figure 2?

- Line 279: I object to the use of fully self-consistent here as this is about test particles.

- Figure 9, lines 285 and 289: The text mentions 3 gyroperiods, the figure caption says 10. Which is correct?

- Figure 10: - In the caption, the case not plotted is for Box 1, as others are shown in the left panel. There is on (b) in the figure so that can be removed from the caption too. Can the colour scale be clarified? Is it a derived phase-space density? - It would be good to clarify also in the text: are these distributions a combination of all particles originating in one box, no matter where they ended up spatially? Could the authors illustrate/discuss the impact of this, as opposed to taking the distribution in a given spatial region, which is the more common strategy?

Technical corrections

- The title capitalisation is inconsistent.

- Line 1: "test-particle" (no -s)

- Line 7: on/off; detailed

- Line 18: This copyright statement is incompatible with the license granted at top of each page and on the discussion web page.

- Line 45: A large scale

- Line 48: "until 2 RE" or "up to 2 RE"; RE/Earth radius has not been introduced yet.

- Line 49: First occurrence of E and B, they could be introduced here.

- Line 51: loses

- Line 72: technique

- Line 82 and elsewhere: Alfvén

- Figure 1: time independent; in the fully consistent expansion model

- Line 113 & 116: boxes

- Line 123: a homothetic transformation

- Line 160: depending on

- Line 201: Do you mean "it cannot be necessary" or "it could be unnecessary"? I guess the latter.

- Line 246: stationary

- Figure 8: The lines are black and not blue. And both cases are switched, so black/red are respectively with and without EI.

- Line 275: in a previous paper

- Line 277: correspondence

- Line 282: " missing
- Line 305: followed by
- Line 306: corresponds to a half gyration
- Line 316: taking into account
- Line 320 & 322: the peak amplitude
- Line 322: Fermi
- Figure 9: developed
- Line 330: As is well known
- Line 331: Lembege; "As a consequence" or "Consequently"
- Line 340: during which particles see (no comma); corresponds
- Line 341: mentioned
- Lines 343 and 402: discriminate
- Line 347: accelerates
- Figure 10: "(see Figure 8)" (no "to")
- Line 363 and 367: f1 resp. f2 and not P1, P2, I believe.
- Line 368: At last (?)
- Line 370: look at; roughly
- Line 384: No "Then"
- Line 388: dependence
- Line 397: associated to a
- Line 403: components

- Line 408: extra)
- Line 429: such as
- Line 432: respective
- Line 433: since they are being blurred
- Figure 11: "black" instead of "dark", maybe?
- Line 437: produced

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