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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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This paper presents a comprehensive analysis of novel results from the Vlasiator model for proton and helium acceleration in the Earth's foreshock. The paper is clear and (in general) well written, the conclusions are substantiated by discussion of simulation results and comparison with observations. For the community interested in shock physics, the paper will be very important. For the general space plasma physicist., the results will be fairly important. Some of the results reported in the paper include (1) different edge locations for the proton and helium foreshock, (2) the manner in which the ratio of helium to proton density varies with location in the foreshock, (3) the nature of proton and helium distribution functions as a function of location, (4) the manner by which helium is heated in the foreshock, (5) the effects of the IMF orientation on fore-

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shock boundary structure, and (6) the nature of waves/turbulence in and around the foreshock.

I only have a few comments/questions.

Lines 50-61. I did not find this review of past work as clear as it could be. I have no objection to each sentence but I think it can be presented more carefully. The authors could systematically go through each region of space, or each type of distribution function, showing they are covering all possibilities. A table noting regions, types of distribution functions, and composition ratios would help. Could the authors just tell what is seen first, and then give explanations? Or could they state expectations and then tell what past work has seen? It would be cleaner than the mixture of observations and interpretations.

Having a table would also be something useful that the authors could refer back to when summarizing their work towards the end of the paper, especially if they can check off each observation and state that their model predicted it.

Change:

1. the suprathermal He2+ fraction –> the ratio of He2+ to H densities with suprathermal energies

2. High energy field aligned beams near the foreshock edges show significant He/H ratios, whereas lower energy beams deeper within the foreshock exhibit intermediate proton distributions and lower He/H ratios

3. Still deeper (?) within the quasi-parallel shock, He distributions are nongyrotropic partial rings whereas H distributions are ring beams and density ratios return to solar wind levels.

4. Diffuse ions are found WHERE?. The ratio of suprathermal He to suprathermal H ion densities is similar to that for the solar wind composition.

Lines 100-102. The authors chose to simulate very rare solar wind conditions. There were only 85 hours of solar wind velocity between 700 and 800 km/s and densities less than 3 cmˆ-3 during the 17250 hours in the two-year period of 2012 and 2013 (0.5% of all conditions). Could the authors please add a paragraph to the conclusion stating what they expect the results for more typical solar wind conditions to be?

Line 150 says the simulation finds Nalpha/Nproton > 2 deep in the foreshock. Is that consistent with the summary above? What is the explanation for it? If the paper tells this somewhere and I have missed it, please strengthen the discussion to make it clear. I would have guessed that deep within the foreshock is a region of diffuse ions and I have read above that density ratios for diffuse ions are similar to those in the solar wind, not twice as great.

Line 181-182. When the authors present two case studies of observations they should tell where the spacecraft were located and present a plot showing the locations of the magnetopause and bow shock, the IMF lines, and the locations of the spacecraft. This will help in the comparisons and in the reader's comprehension.

Line 182. Actually it is probably the foreshock moving past the spacecraft and not vice-versa and the authors should make this clear.

In general (1). Where are the spontaneous hot flow anomalies reported and simulated to occur within the quasi-parallel foreshock? [Zhang et al., JGR, 118, 3357, 2013; Omidi et al; JGR, 119, 9823, 2014]

In general (2) Do the authors find foreshock compressional boundaries with density and magnetic field strength enhancements like those reported by Omidi et al. [JGR, 118, 823, 2013]? If so, where do these boundaries lie compared to those for the patterns for waves and suprathermal composition ratios?

I caught a few typos/corrections.

1. Author list. Stephen 2. Line 15. The –> to 3. Wilson III –> Wilson 4. Line 36

dynamical –> dynamic

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