Nonlin. Processes Geophys. Discuss.,
https://doi.org/10.5194/npg-2018-43-RC2, 2018


Nonlinear Processes in Geophysics
Discussions

# *Interactive comment on* "Ion acceleration at dipolarization fronts associated with interchange instability in the magnetotail" *by* Chao Sun et al.

**Anonymous Referee #2**

Received and published: 22 November 2018

The paper is devoted to the study of ion acceleration in the dipolarization front of the Earth's magnetotail. The paper focuses on the effect that an instability of the interchange kind can have in the ion energization. The authors use a test particle approach to study the acceleration process. The fields are provided by a 2D Hall MHD simulation. The authors argue that the interchange instability is responsible for ion acceleration and that the Hall electric field plays a crucial role in the process of energization and transport. In my opinion the paper contains potentially interesting results, but, before being reconsidered for publication, the authors should implement major revisions on their manuscript.

1) In order to set the value of the electric field in the simulation similar to that observed by in-situ measurements, the authors make a strong assumption on the initial condition.



This assumption has to be justified by physical arguments. Since the set-up is not an equilibrium, the author should provide theoretical evidences that the configuration they are considering can dynamically form, or is at least likely to be present, in the magnetotail. Moreover, I suggest that the authors plot the initial profiles of the most important quantities as a function of "x" in the case of the quasi-stationary equilibrium and in the case used for the Hall MHD simulation.

2) What boundary conditions are used for the particles? What happens to a particle that reaches the "x" or "y" boundary? Why is there an accumulation of energetic particles at y=0? This doesn't seem to be a physical effect.

3) The parameters used for the Hall MHD and the test-particle simulations must be specified. How many grid cells where used in the Hall MHD simulations? Are the electric and magnetic field coming from the Hall MHD simulation interpolated in space and time to advance particle evolution? How is this interpolation done? Which method is used for integrating the trajectories? How does the time step used to compute particle trajectories compare with the ion gyroperiod and with the time unit of the simulation? What is the direction of the test-particles initial velocity? How does the initial Larmor radius compare with the grid size?

4) In order to show an actual energization of the ions, the author should provide the PDF of particle energy at the beginning and at the end of the simulation.

5) Are the particle free to move along z? Due to the 2D field, particles do not see any field variation along z. This rules out processes such as pitch-angle scattering along Bz which can influence particle transport. The author should discuss this limitation.

The following are minor revisions.

14: The authors state that "It has been shown . . . in the magnetotail". Can they please provide a reference for this statement?

41: "SC" has not been defined previously.

54-57: “Spacecraft observations showed that . . . in the magnetotail”. Either this sentence is incomplete or the word “that” has to be removed.

64: Maybe substitute “along” with “by”.

70: Isn’t it better to put a full stop rather than a comma after “. . . that ahead of it” ?

96-100: “Since the DF is produced by temporal . . . in the magnetotail”. I don’t see the connection between the sentences before and that after the comma. For example, wouldn’t it be more meaningful to study this problem using a truly self-consistent PIC code?

108-109: What does it mean that ions trajectories are tracked “backward” in time?

115-117: Please explain in more details where the gravity term comes from.

125: “gx” is not contained in Equation 1.

133: Where does “p/6” come from? What is the definition of “beta”?

218-220: At what time is Figure 3 plotted?

221-231: This part on the variation of the pdf along x is kind of obscure to me. What is it meant to show?

331 (Figure 7): How are w, w1 and w2 defined?

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