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Interactive comment on "Crescent-shaped electron velocity distribution functions formed at the edges of plasma jets interacting with a tangential discontinuity" *by* Gabriel Voitcu and Marius Echim

Anonymous Referee #1

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General comments:

The manuscript "Crescent-shaped electron velocity distribution functions formed at the edges of plasma jets interacting with a tangential discontinuity" by G. Voitcu and M. Echim discusses a mechanism explaining the formation of crescent-shaped electron distribution functions by means of fully-kinetic 3D PIC simulations of plasma clouds deflected by tangential discontinuities.

The manuscript is well written and clear. It shows an interesting and physically clear

explanation for the now commonly observed crescent shaped electron distribution functions in the Earth's magnetosphere (in particular near magnetic reconnection regions). The Figure 4 with the schematics of the mechanism is particularly helpful, emphasizing the role of the filtering of high vs low energy electrons by the gradient-B drift plus a remote sensing effect in magnetic gradients (without field reversal as in typical magnetic reconnection geometries). I also appreciate the details given for the calculation of the distribution functions (precise location) and virtual satellites. As I far as I know, I was not aware of other works pointing out to this mechanism for crescent-shaped (or non-gyrotropic in general) electrons distribution functions in this scenario. I do not see any major problem with the interpretation of the results of the PIC simulations. I would only ask the authors for some clarifications and additional details about the initial setup of those simulations, in order to guarantee reproducibility of the results.

Specific comments:

1) This manuscript points out to two earlier papers [Voitcu2016], [Voitcu2017] for the description of the simulation setup. But in order to be more self-contained, I would ask the authors to add some important parameters to the text. In addition, I could not find anywhere the values of other critical quantities (or at least it was not clear to me where to find them or calculate them). I think the manuscript and its readers will benefit of those details. i) ion or electron plasma beta of the plasma jet including only thermal pressure (not the bulk velocity). Or equivalently, the value of the electron thermal speed. The value of eta=500 allows to obtain omega_pi/omega_ci, but the ion (or electron) thermal speed are still needed to determine other quantities. ii) What are the boundary conditions? (I know that this is mentioned in previous papers, but nothing here) iii) How far away are the boundaries with respect to the plasma cloud and/or tangential discontinuities? Table 1 of [Voitcu2016] is not clear regarding this: the simulation box is expressed in number of grid points, but it is more helpful to convert it to electron gyroradius or other physical units (the lengths in all the figures should also be normalized to some meaningful physical units, if possible). iv) What is the number

of particles per cell and/or the total number of particles?

2) One parameter that I am puzzled about is the grid resolution. Table 1 of [Voitcu2016] says that Delta x/lambda_De = 2.5. Is it exactly the same for this paper? If so, that would indicate an under-resolved grid cell size, possibly leading to numerical heating. Is there any indication of that effect? How well conserved is the total energy in those simulations? Have the authors used some high order shape function or some kind of current smoothing to prevent numerical heating? And how well resolved is the electron gyroradius compared to the grid cell size? (this quantity should also be well resolved).

3) I understand that the proposed mechanism for the formation of crescent shaped electrons is based on the remote sensing of electrons with an electron gyroradius on the order of the magnetic field gradient in a tangential discontinuity. As mentioned in the references of this manuscript, similar mechanisms were proposed for ions, which have a much larger gyroradii and therefore they are much easier to detect. Is there any chance to actually measure in-situ such a steep magnetic field gradients? (in the Earth magnetosphere, for example by MMS). I am not sure about that, in particular considering the low-beta plasma used in this simulation study, which implies a very small electron gyroradii. I would appreciate if the authors could add some studies with explicit numbers for measured tangential discontinuities (and corresponding electron gyroradii), please.

4) Related to the previous question: How about high-beta plasma effects? In this parameter regime, the electron gyroradii would be larger and easier to measure. Would there be any significant different for the proposed mechanism in that parameter regime? Have the authors tried such simulations? If not, why not? In such cases electrostatic effects such as polarization electric fields should be diminished. I think a brief discussion about this issue will benefit the readers by making the results of this manuscript more general and with a wider applicability.

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