Replies to referee 1

[Authors] We thank the referee for the provided feedback. Please find below the point-by-point replies to the raised questions and comments. A list of references is provided at the end of this document

The authors present a comparison between local (LPC) and global (GPC) current-free boundary conditions applied to an axisymmetric, hybrid simulation of a Hall effect thruster. They apply these boundary conditions to three separate system configurations: one with an external cathode (EC) inside the magnetic field separatrix (MS), one an EC outside the MS, and one with an internally mounted cathode, using four separate domain sizes, i.e., 12 different cases. In the revised manuscript the authors increase the emphasis on the importance of the cathode location with respect to the GPC and LPC, as the external configuration is very sensitive to the boundary condition. Many of the observed qualitative trends are compared to experimental data for partial validation.

No major comments.

Minor comments:
1) It is appreciated that the authors added detailed references on where to find the numerical details of the code in prior works.

Thank you.

2) In the discussion of equation (2), it is stated that there is “no clear criterion for defining the constant c.” This is the result of assuming a functional form for P’’_neP based on a Maxwellian VDF, where in reality non-Maxwellian effects lead to a deviation from the c = 5/2 condition as a “best fit.” Is there a discussion of the physical relevance of these values for c in the cited papers? A brief discussion of the modified coefficient may strengthen the scientific justification for modifying this value.

We recall that the constant c is only used by the LPC model, and not by the GPC model. Its value is uncertain since the LPC does not model the electron dynamics in the off-simulation region from P to infinity. To our knowledge, cited papers do not elaborate much on the value of c. Only Ref. [1] studies the influence of the value of c on the electron temperature profile for different plume sizes, and finds that c = 9/2 (equivalent to $q_{ne} = 2n_e T_e u_{ne}$) provides the best match. This is the value of c used in our study when the LPC is applied. On the other hand, as we comment in Section III of the manuscript, our results indicate that the equivalent value of c when the GPC is applied ranges from 4 to 9.2. The value of c = 9/2 used by the LPC is thus within that range.

3) This statement is unclear: “In the last case, a higher cathode coupling voltage is expected to bring part of the electron emission into the thruster channel.”

Thank you. The sentence has been reformulated for the sake of clarity. It now reads as follows: “In the latter configuration, the coupling between cathode-emitted electrons and the ion beam exiting the thruster channel is expected to become less efficient and require a higher cathode coupling voltage to drive part of the emitted electron into the channel.”

4) The generalizability of the GPC to non-zero currents is interesting, and the additional details are appreciated.

Thank you.

5) In figures 2 and 3 the black cathode marker is difficult to see. I would recommend using a different color or adding an outline to the marker.

Ok. The cathode marker is now larger, white and has an outline, according to the referee.

6) The authors’ response explaining the thrust calculation is appreciated. I believe it would also be worthwhile to include this information in the manuscript.

Thank you. According to your suggestion, we have detailed the thrust computation at the beginning of the Appendix A in the revised version of the manuscript.

REFERENCES

[1] Zhou, J., Domínguez-Vázquez, A., Fajardo, P. and Ahedo, E., “Magnetized fluid electron model within a two-dimensional hybrid simulation code for electrodeless plasma thrusters”, Plasma Sources Science and Technology, Vol. 31, No. 4, 2022, pp. 045021.