1 Report

by Gullik Vetvik Killie, Add yourself

Abstract

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1.1 Introduction

- State of the art
- Why are we doing this
- What is being done
- Aims of report/study (want to see if)

We are using something to prove something!!!

1.2 Theory

1.3 Numerical Methods

- Short PiC (EMSES) explanation
- Experimental set up
-

1.3.1 Numerical methods

To solve the problem numerically we use the EMSES code. EMSES uses the standard PIC method for plasma simulations. In the code we are able to define a spacecraft body, and the code then calculates the potential on that body using the capacitance matrix method. Although EMSES has the capability to do a full electromagnetic calculation, we have opted to use the poisson's equation solver for electrostatic problems. In the EMSES system we can define sunlit surfaces based upon an angle, and a current desity. Sunlit surfaces will then emmit electrons based upon a energy distribution. For a complete description of EMSES' capabilities see (Nakashima et al., 2009) Parameters are choosen to simulate the earth, but with an enhanced flux to emphasize the effect in question.

1.3.2 Test case setup

We wish to simulate the effects of Photon emmision in different test cases, and have thus set up the following 6 cases:

Case	Plasme flow	Photon emission
1:	41600 $\vec{e_x}$ m/s	0
2:	-41600 $\vec{e_z}$ m/s	0
3:	-41600 $\vec{e_y}$ m/s	0
4:	41600 $\vec{e_x}$ m/s	$-10^{-3}A/m^3\ \vec{e_x}$
5:	-41600 $\vec{e_z}$ m/s	$-10^{-3}A/m^3\ \vec{e_x}$
6:	-41600 $\vec{e_y}$ m/s	$-10^{-3}A/m^3\ \vec{e_x}$

So test case 1-4, 2-5, and 3-6 are the "same" cases exept that we run the simulation with and without photon emission to compare the cases two and two.

1.4 Results

- Comparison of cases with P-E and without
- Acc of charges at probes + ϕ, diff flows and α
- ϕ num vs ana

1.4.1 Induced electric current

The plasma is flowing in in relation to the coordinate system in the simulations. Due to this an induced electrical field, ε, that neutralizes the Lorentz force.

$$\vec{\varepsilon} = \vec{v_D} \times \vec{B} \tag{1.1}$$

This will cause a potential gradient perpendicular to the plasma flow and the magnetic field, using the electrostatic approximation we obtain the magnitude of the gradient.

$$\int E dx = -\phi \tag{1.2}$$

$$|\nabla\phi| = |\vec{v}_D \times \vec{B}| \approx -\int (41600\text{m/s} \cdot 50E-6\text{T})\, dx \tag{1.3}$$

$$|\nabla\phi| = 2.08\text{m}^{-1} \tag{1.4}$$

Figure **??** shows the measured potential at case 6.

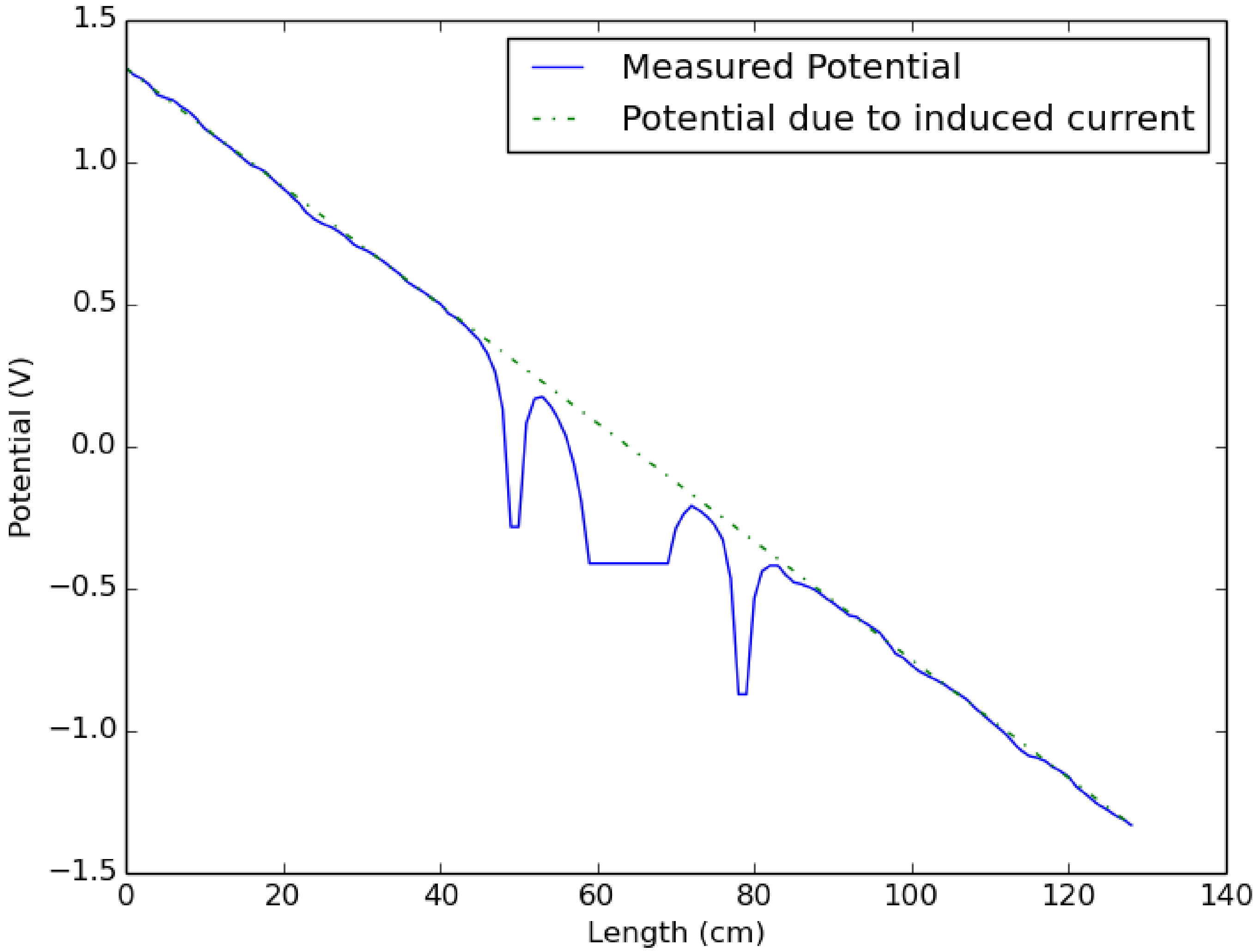


Figure 1.1: The blue line is the potential along direction x for simulation 6. In this case the potential gradient is along the $x-$axis. The dotted green line is the potential caused by the induced electrical field. This should be accounted for if we want to find the potential at the spacecraft and the probes.

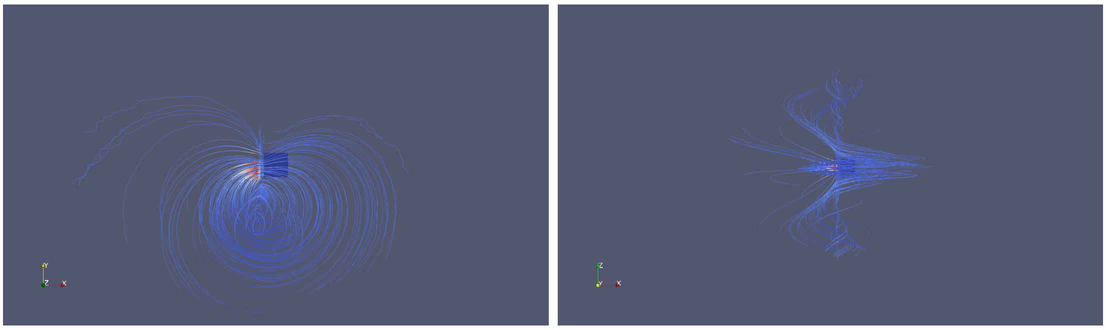


Figure 1.2: The trajectories of the electrons emmited by the photoelectric effect in simulation 6. The possible paths of the photoemmited electrons coincide with the volume occupied by the langmuir probes. The photoemmited electrons are strongly affected by the magnetic field $\vec{B}$, and follows a gyrating path guided by $\vec{B}$. The photoemmited electrons are in all the studied cases emmited from the spacecraft in $-x$ direction, and the paths are similar. The langmuir probes are situated 10cm to each side of the spacecraft along the $x-$direction. (NOTE, should have axis labels, and domain length.)

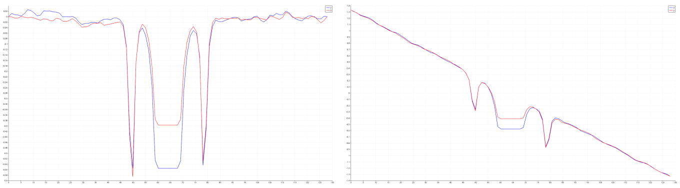


Figure 1.3: Potential of spacecraft and surroundings with P-E and without P-E. Figure on the left displays difference between case 1 and 4. Middle figure displays difference between case 2 and 5. Rightmost figure displays difference between case 3 and 6.

1.4.2 Photoemmision paths

The electrons emmited from the spacecraft due to the photoelectric effect, have a kinetic energy corresponding to a Maxwellian distribution with a temperature of $T_{ph} = 3.8481 \cdot 10^4$K. Figure 1.1 illustrates the trajectories of the emmited electrons in simulation 6. As the probes are situated 10cm to the sides of the spacecraft on the $x-$axis, the probes may be hit by the photo-emmited electrons. In the following section, **??**, we show the number of electrons hitting the probes.

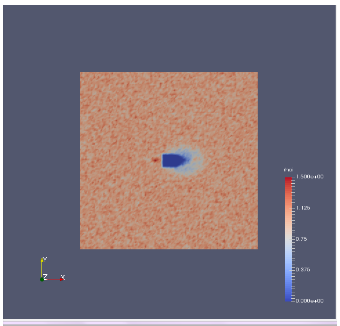
1.4.3 Potential difference with P-E and no P-E

Case 1 vs case 4

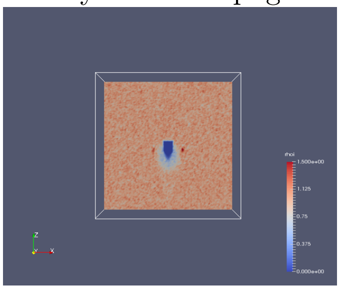
Need plot

Case 2 vs case 5

With the flow of emmited electrons in the negative x direction we would expect a rise in electron density around the left probe. This can be seen in the potential of this probe density case1.png



density x-z case2.png



density x-y case3.png

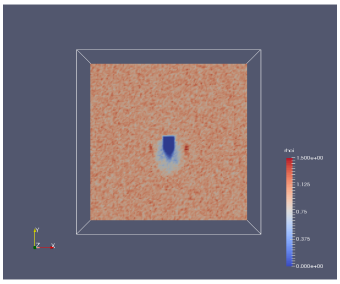


Figure 1.4: Ion density of spacecraft and surroundings without P-E. Figure on the left displays case 1. Middle figure displays case 2. Rightmost figure displays case 3.

where there is a 5.4% drop in the potential of this probe compared to no emitted electrons. On the right probe we have a small rise in potential of 3.3%. With no emitted electrons on this side of the satelite the rise in potential can be explained by looking at the increase in ion density as seen in figure (need ref). In the satelite we have a potential rise of 28%. So the change in potential in the probes are small compared to the change in the satelite.

Case 3 vs case 6

A rather large drop in potential of 12% on both probes. Potential rise of 26% over the satelite.

1.4.4 Wake plots

1.5 Discussion

1.6 Conclusions

- Proposal for further studies (Probably see if photoemmision is relevant in tenous plasma (MEO CASE, magnetospheric tail lobes))