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Simulation of currents collected by a spherical probe with PTetra

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Spacecraft interaction with space environment is of much interest as satellites in orbit encounter robust space weather conditions mostly originated from the sun to the interstellar medium. This can lead to space borne and ground-based technologies. Hence, there is a need for simulating the space plasma parameters (velocities, frequencies,...) for space weather forecasting and warning to users. The present work does simulations of plasma currents (electrons/ions per second) collected by a spherical probe. The spherical geometry of the probe is generated with Gmsh, an open source for mesh generator, starting with a .geo file in which the outer sphere radius is ten times bigger than the inner one. The mesh resolution (specified in the .geo file) is such that it resolves the Debye length (2 to 3 Debye lengths) everywhere in the simulation domain. Simulated values of the collected currents were obtained by running a PTetra simulation code developed by Prof. Richard Marchand at University of Alberta, Canada [1] until a steady state is reached after injection of ions and electrons. Simulation parameters used in the PTetra code such as electron and ion temperature (equal and in eV) are calculated from the Debye length formula by assuming that the plasma is neutral (electron density=ion density), singly and fully ionized. On the other hand, the probe potential parameter is calculated via the ratio between thermal energy (kT) and potential energy (eU). In order to evaluate the performance of PTetra in simulating the plasma parameters, the currents collected by the spherical probe are normalized to their numerical values (computed at plasma potential=probe potential) by assuming an unmagnetized and Maxwellian plasma such that ions and electrons of one species are in a thermodynamic equilibrium. The results of normalized collected currents from PTetra code display a percent deviation of about 2% by varying the ratio between the potential energy and the thermal energy from 1.5 to 25. While changing the ratio between the probe radius and the Debye length (in mesh generation) from 0.5 to 5, the percent deviation is found to be around 1.5% compared to the values found by Laframboise [2]. Overall, PTetra predicts very well the plasma parameters (collected currents) and the future work is to include many ion and electron species, velocities and consider more realistic probe geometries such as Swarm and ePOP.

References

1. R. Marchand, “PTetra, a tool to simulate low orbit satellite–plasma interaction,” *IEEE Trans. Plasma Sci.*, **40**, 2, February 2012, pp. 217–229

2. J. G. Laframboise, “Theory of spherical and cylindrical Langmuir probes in a collisionless, Maxwellian plasma at rest,” Ph.D. dissertation, Univ. Toronto, Toronto, ON, Canada, 1966