Steady Euler-Poisson system for LEO Spacecraft Charging

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Spacecraft charging is defined as those phenomena associated with the buildup of charge [4]. Indeed, spacecraft systems interact with the ambient plasma environment. Due to their mobility, charged particles (electrons, ions) hit external surfaces and, with the ionization effect by solar UV or high energy particles, lead to the accumulation of a net electrical charge on spacecraft surfaces. An electrostatic potential difference between the spacecraft surface and the plasma, varying from a negative charge of many kilovolts to a positive charge of a few tens of volts, results from this accumulation of charges. Spacecraft engineers and scientists need to predict these effects to improve the design and the performance of space systems and to get an understanding of their actual behaviour in space [1, 2, 3]. We address the question of modeling and simulating spacecraft charging in low earth orbits. In low earth orbits (around $1400km$), we are interested in two distinct situations. First, a region LEO in which the plasma density is of the order of 106 $cm^3$and the temperatures are 1000 to $2000K$. Second, a region PEO in which the plasma density is of the order of 103 cm^3at the same altitude, and the plasma temperature is in the range $1 - 10kev$. Depending on the regions, different models are designed [5]. We derive hierarchies of models depending on the environment, respectively referred to as the Euler- Poisson model and the Vlasov-Poisson model. The Euler-Poisson model is suitable for the cold ionospheric plasma (LEO), while the Vlasov-Poisson model is better suited to PEO. We discuss precisely the dimensionless form of the equations, relying on a suitable choice of scaling units. A specific attention is paid to the boundary conditions which are crucial in the description of the charge phenomena [3]. The scaling discussion will be the necessary preliminary step to construct adapted numerical schemes.

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