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NUMERICAL SIMULATION OF SOLAR WIND - SATELLITE INTERACTION IN THE SOLAR CORONA REGION

Abstract

With the purpose of solving the Solar Corona heating process mistery, current scientific efforts are trying to provide in-situ measurements of plasma properties in this region. In this scenario, it becomes important to understand the interaction between the Solar wind at the Solar Corona and the surface of a probe.

In order to study probe surface charging, but also be able to consider more complex phenomena that may arise when considering Solar Corona-Probe interactions, it seems valuable to create a program that can integrate and run different types of geometries and plasma-related numerical methods simultaneously. With this aim, in the present study a program called SCSI (Solar Corona Satellite Interaction) has been created.

The code focuses on high modularity in its architecture and program flow, therefore allowing to easily interchange different types of meshes, time integrators, electromagnetic solvers, etc. Additionally, the domain of the simulation is constructed in an object-oriented tree-like fashion, enabling the domain to function as separate entities that work independently and interact only through their boundaries. This strategy allows to execute different numerical methods in different regions of the domain and inherently provides mesh refinement for studying multi-scale phenomena.

Having multiple subdomains at different scales in the code is essential to numerically represent the physics of Solar wind-Probe surface interactions. On a small scale, photoelectrons and secondary emission electrons produced on a probe have Debye length values of around $2 \sim 4\,\mathrm{cm}$; therefore, phenomena such as Debye shields or potential wells are expected in this range. On a bigger scale, the electron population of the solar wind has a Debye length of around $1\,\mathrm{m}$, and the probe itself has dimensions of the same order; thus, electrons and protons also react to the presence of the spacecraft at this scale. The architecture of the SCSI program was conceived with the intention of capturing all these different phenomena with acceptable accuracy, as well as giving the possibility to choose the best set of numerical tools for each region of the system.

At present, the code is being validated through the simulation of a satellite immersed in the Solar Corona region at a distance of $9.5\,\mathrm{R}_{\odot}$ from the surface of the Sun, and comparing results with existing literature. This configuration has been chosen in order to study the conditions that the Parker Solar Probe will face during its approaches to the Sun.