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International collaborative study on spacecraft-plasma interactions in the near-Sun environment

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Space exploration and exploitation have been rapidly increasing, and a strong demand arises regarding comprehensive understanding of spacecraft-plasma interactions. Numerous numerical tools have been developed in response to such requests, such as Nascap-2k, SPIS, MUSCAT, and other original codes developed by individual researchers. However, it is difficult to understand diverse conditions of spacecraft-plasma interactions by using only one model, because each model has its own advantages and disadvantages depending on employing numerical schemes and modeling techniques. Hence, we have organized an international team for the study of spacecraft-plasma interactions from 2011 and worked on a common problem via multiple numerical tools.

As one of such collaboration activities, we study on the physics of spacecraft-plasma interactions in the near-Sun environment. The spacecraft environment immersed in the solar corona is characterized by a large photoelectron emission current caused by an intense solar flux and a secondary electron emission current due to ambient plasma impingement on the spacecraft surfaces, which lead to much different nature of spacecraft-plasma interactions from that in the near-Earth environment. Consequently, the spacecraft is reported to be charged negatively near the Sun unlike usual photo-emitting spacecraft in the near-Earth environment. In the present study, we reproduce the plasma environment around the Solar Probe Plus satellite planned by NASA by using the multiple numerical tools. We particularly focus on the properties of negative potential barriers created by a dense photoelectron cloud and the wake structure behind the spacecraft to understand the process of spacecraft-plasma interactions. We will show some preliminary simulation results mainly obtained from our original PIC simulator EMSES.

Keywords: spacecraft-plasma interactions, solar coronal plasma, spacecraft charging, photoelectron emission, spacecraft wake, PIC simulation