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LOW-ENERGY IONS AROUND COMET 67P/CHURYUMOV-GERASIMENKO

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Abstract

Low-energy ions play important roles in the formation of the plasma environment around a comet. Reliable ways of measuring these ions are therefore of high importance to fully understand the processes and dynamics of this environment. Unfortunately, low-energy ions are infamously difficult to detect. A spacecraft interacts with the surrounding environment, which leads to an accumulation of charge on the spacecraft surface. As a result, the surface acquires an electrostatic potential with respect to the surrounding plasma, which can be either positive or negative. Low-energy ions are then attracted to or repelled from the charged surface before being detected by the instrument on board, resulting in an energy shift and change of travel direction of the ions.

The Rosetta mission studied comet 67P/Churyumov-Gerasimenko during the years 2014-2016, and provided the most detailed observations of a comet and its environment to date. The Ion Composition Analyzer of the Rosetta Plasma Consortium (RPC-ICA) measured positive ions in the cometary environment with energies down to just a few eV. The low-energy part of the data is, however, difficult to interpret due to the distortions caused by the spacecraft potential.

In this thesis, the Spacecraft Plasma Interaction Software (SPIS) is used to correct the low-energy ion measurements made by RPC-ICA for the effects introduced by the spacecraft potential. The distortion of the effective field of view is modelled for different ion energies and plasma environments, and the results are used to correct the flow direction of low-energy ions around the comet. The FOV distortion can be considered insignificant when the energy of the ions (in eV) is twice the value of the spacecraft potential (in volts). The FOV distortion at lower energies is geometry dependent, and varies substantially between different pixels of the instrument. The FOV distortion is furthermore dependent on the Debye length of the surrounding plasma.

The knowledge obtained from the simulations is subsequently used to study the flow direction of low-energy ions in and around the diamagnetic cavity, a region where the magnetic field is essentially zero and low-energy ions are important for the dynamics. Evidence of counter-streaming ions are found, with ions flowing both radially away from and back towards the nucleus. SPIS is also used to model the influence of the spacecraft potential on the energy spectrum of the ions, and from this the bulk speed and temperature of the low-energy ions in the diamagnetic cavity were determined to 5-10 km/s and 0.7-1.6 eV, respectively. The bulk speed is significantly above the speed of the neutral particles, indicating a weak coupling between ions and neutrals in the diamagnetic cavity.

Keywords
Low-energy ions, spacecraft charging, comets, 67P/Churyumov-Gerasimenko, Rosetta, RPC-ICA, SPIS, diamagnetic cavity, field of view, plasma, space plasma physics

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