Rosetta electric field observations in the plasma environment of comet 67P/Churyumov-Gerasimenko

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The plasma environments of active comets are dominated by the interaction of the solar wind with newly born cometary heavy ions, predominantly water group ions produced by ionization of cometary neutral volatiles over large distances in the extensive and diffuse cometary coma. The resulting vast comet-solar wind interaction region hosts a plethora of plasma instabilities, waves and turbulence phenomena, and thus constitutes a formidable natural laboratory for studying such processes.

Waves are also important in determining many of the plasma properties of this environment. They can, e.g., heat or cool plasma populations, create supra-thermal electrons responsible for X-ray emissions, reduce plasma anisotropies and gradients, couple different plasma species, and provide anomalous resistivity.

Electric field measurements in the cometary plasma environment have until recently been rare, and have only been performed during short fly-by missions, at relatively large distances from the comet nucleus. The electric field measurements by the LAP instrument onboard the Rosetta spacecraft, collected during more than two years in the vicinity of comet 67P/Churyumov-Gerasimenko therefore represent a truly unique data set.

We use the database of 60 Hz electric field measurements of waves in the lower-hybrid frequency range, and correlate the comet-related parameters, (relative spacecraft position, solar distance, plasma and neutral gas density, etc.) with wave related parameters, such as amplitude/spectral density and frequency. We also compare statistically the properties of the waves with theoretical predictions of lower-hybrid wave generation, regarding e.g. amplitude dependence on plasma density gradients, with the aim of clarifying the importance of the plasma waves in different
regions of the cometary plasma environment.

Electric field measurements allow investigating both electrostatic wave modes and electromagnetic ones. We investigate frequencies and amplitudes of the electric field oscillations and use background magnetic field values and plasma properties to determine relevant expected frequencies, as well as magnetic field oscillations (for low and medium frequencies) to determine if the plasma waves are electrostatic or electromagnetic. Lower hybrid waves are almost electrostatic, but have a small magnetic field signature from second order effects. Determination of the most common wave modes gives an indication of the role of plasma waves in the cometary plasma environment probed by Rosetta.

Lower hybrid waves are common in the inner coma of 67P. Such waves are predicted to energize electrons parallel to the ambient magnetic field, and ions in the perpendicular direction. With the help of ion and electron data, we test this prediction, which may explain the presence of a hot electron population reported on, but of hitherto unknown origin. These results give clues to the role of the waves in the formation of the cometary plasma environment.