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Ionospheric composition of comet 67P near perihelion with multi-instrument Rosetta datasets

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The European Space Agency Rosetta mission escorted comet 67P/Churyumov-Gerasimenko for two years, during which it acquired an extensive dataset, revealing unprecedented detail about the neutral and plasma environment of the coma. The measurements were made over a large range of heliocentric distances, and therefore of outgassing activities, as Rosetta witnessed 67P evolve from a low-activity icy body at 3.8 AU to a dynamic object with large-scale plasma structures and rich ion and neutral chemistry near perihelion at 1.2 AU. One such plasma structure is the diamagnetic cavity, a region of negligible magnetic field surrounding the comet nucleus. It is formed through the interaction of the unmagnetized outwardly expanding cometary plasma with the incoming solar wind. This region was encountered many times by Rosetta between April 2015 and February 2016, as the comet moved towards and away from perihelion.

In this study, we focus on the changing role of chemistry during the escort phase, particularly on trends in the detection of high proton affinity species near perihelion and within the diamagnetic cavity. NH_4^+ is produced through the protonation of NH_3 which has the highest proton affinity of the neutral species and is therefore the terminal ion. The ratio of this species to the major ion species H_3O^+ can then be an indicator of the importance of ion-neutral chemistry as an ion loss process compared to transport. We use data from the high resolution mode of the ROSINA (Rosetta Orbital Spectrometer for Ion-Neutral Analysis)/DFMS (Double Focussing Mass Spectrometer) instrument, which allows certain ions of the same integer mass per charge ratio to be separated from one another, most importantly H_2O^+ and NH_4^+. This data is then analysed alongside a range of plasma properties from the RPC (Rosetta Plasma Consortium) suite of instruments, to determine features of the plasma within and outside of the diamagnetic cavity that may systematically impact the ion species detected in the mass spectrometer, for example through the spacecraft potential.

For the same period, ion ROSINA/DFMS ion data are analysed together with simultaneous observations of the cometary plasma properties by RPC instruments, in order to identify systematic plasma features or biases which may impact the ion composition detected by ROSINA. In addition, the ion composition measurements are compared to ionospheric simulations. We evaluate the relative significance of ion-neutral chemistry and transport such that their impacts on the ion composition in different interaction regions are identified.