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Cometary "ion" zoo at comet 67P revealed by ROSINA/DFMS

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Abstract

For two years, Rosetta gave us the unprecedented opportunity to escort and "sniff" the coma of comet 67P/Churyumov-Gerasimenko with its onboard mass spectrometer, Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA)/Double Focusing Mass Spectrometer (DFMS) [1]. Its primary goal was to identify the neutral composition thoroughly, atomic, molecular [2, 3, 4], and isotopic constituents [5, 6], which are present in the coma of 67P. However, at times, ROSINA/DFMS also offered us the opportunity to probe the positive ion composition and its evolution along the cometary orbit as well as to identify the ion species. Indeed, prior to Rosetta, previous missions only gave us a snapshot as they were only flyby and did not have a sufficient mass resolution. For instance, it could not differentiate H_2O^+ from NH_4^+ at mass 18 u·q^{-1}. In addition, only a few ion species, such as CH^+, N_2^+, and CO^+, have been detected in remote-sensing (with Ultraviolet spectrometer or from ground-based observatories). Many ions were proposed as candidates at each mass-per-charge peak detected onboard planetary spacecraft, constrained by the neutral composition and photo-chemical models. This left ion identification very uncertain.

Thanks to the high mass resolution of DFMS and recent improvement of its calibration, a large part of the ion species has been successfully identified unambiguously and/or confirmed, most being detected near perihelion. In addition, we show that some ions stem from ion-neutral chemistry as they may not originate from direct ionisation of the neutrals, such as NH_4^+, previously identified [7].

We present here a comprehensive overview of the different ions detected and identified at 67P, while focusing on the range from 13 to 40 u·q^{-1}. Moreover, we provide the evolution of ion composition with heliocentric distances. We highlight the exciting discovery of unexpected ions and discuss their origin.

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