Guiding electron to neutral number density ratios in the coma of comet 67P/Churyumov-Gerasimenko throughout the pre-perihelion phase of the Rosetta mission

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Abstract

We combine TIMED/SEE solar EUV spectra [1] with photoionization cross section sets [2] to derive partial photoionization frequencies of H$_2$O, CO and CO$_2$, the dominant molecules in the coma of comet 67P/Churyumov-Gerasimenko [3]. The values are in accord with earlier estimates [4] although with some differences regarding the yield of minor product ions. The computed H$_2$O ionization frequency in the coma of 67P is estimated as a function of time (and heliocentric distance) from August 2014 to August 2015, from the rendezvous of Rosetta with 67P at ~3.6 AU to perihelion at ~1.25 AU. This time-dependent ionization frequency is used together with an adopted radial speed of the cometary neutrals of 650 m/s [5] to generate a guiding electron to neutral number density ratio, $G_{e/N}(r,d)$, as a function of cometocentric distance, $r$, and heliocentric distance, $d$. We present a parameterization of $G_{e/N}(r,d)$ and argue that comparisons of observations with $G_{e/N}(r,d)$ is a useful method to gain insights into physical and chemical processes at play in the cometary coma. Minor deviations, by up to a factor of 2 or so, can result from missing ionization processes and by variations in the chemical composition, in the impinging solar EUV irradiation, or in the neutral’s outgassing speed profiles. Such effects are accounted for in Ref. [6]. Major deviations, with $G_{e/N}(r,d)$ being significantly higher than ratios observed, can result e.g., from the effect of electric fields accelerating the ion population or, near perihelion, by attenuation of the solar EUV irradiation, by the increased importance of dissociative recombination as a plasma neutralizing mechanism [7] and possibly also, by nanograin charging [8]. Observations by LAP, MIP and ROSINA onboard Rosetta at $r=10$ km and $d=3.2$ AU indicate an electron to neutral number density ratio of 1-2x10$^{-6}$ [9]. This is surprisingly well in resemblance with our $G_{e/N}(r=10$ km,$d=3.2$ AU) value of 1.0x10$^{-6}$. Further comparisons with observations will be presented at the meeting.

References

We compute partial photoionization frequencies of H2O, CO2, and CO, the major molecules in the coma of comet 67P/Churyumov-Gerasimenko, the target comet of the ongoing ESA Rosetta mission. Values from a view via Publisher. kth.diva-portal.org. Save to Library. Save. Create Alert. Alert. View via Publisher.

We report the detection of argon and its relation to the water abundance in the Jupiter family comet 67P/Churyumov-Gerasimenko by in situ measurement of the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) mass spectrometer aboard the Rosetta spacecraft. Despite the very low intensity of the signal, argon is clearly identified by the exact determination of the mass of the isotope (36)Ar and by the (36)Ar/(38)Ar ratio. Because of time variability and spatial heterogeneity of the coma, only a range of the relative abundance of argon to water can be given. Nevertheless, this range confirms that comets of the type 67P/Churyumov-Gerasimenko cannot be the major source of Earth's major volatiles. Molecular nitrogen in comet 67P/Churyumov-Gerasimenko indicates a low formation temperature. Science 348, 232â€“235 (2015). CAS Article ADS Google Scholar. Andre Bieler et al. report the detection and in situ measurement of O2 in the coma of 67P/Churyumov–Gerasimenko, made by the Rosetta spacecraft's ROSINA instrument between September 2014 and March 2015. The data reveal local abundances of O2 between 1% to 10% relative to H2O. The O2/H2O ratio is consistent throughout the coma and does not change systematically with distance from the Sun, suggesting that primordial O2 was incorporated into the nucleus during the comet's formation. Current Solar System formation models do not predict conditions that would allow this to occur. Comet 67P/Churyumovâ€“Gerasimenko. A further era of cometary investigation started with the Rosetta space mission to 67P/Churyumovâ€“Gerasimenko. Rosetta was the first space mission to travel alongside a cometary nucleus as it moved through perihelion. This enabled the spacecraft to observe changes in the cometâ€™s activity and associated modifications to its landscape (El-Maarry et al.). Gases in the coma of comet 67P were measured by the ROSINA instrument (Rosetta orbiter spectrometer for ion and neutral analysis), which has identified an impressive array of molecules in the coma. The list has grown over time as more results have been processed and is likely to grow further. Relevant data can be found in a range of sources, e.g. Le Roy et al. 2007) around comet 67P/Churyumov-Gerasimenko (hereafter referred to as 67P; Churyumov & Gerasimenko 1972). The Rosetta spacecraft monitored the cometary plasma environment from 2014 August 6 to 2016 September 30. During this time interval, comet 67P moved from a heliocentric distance of âˆ’3.6 au toward the Sun, attained a perihelion distance of âˆ’1.2 au from the Sun, and again moved away from the Sun as far as âˆ’3.8 au until the Rosetta operations were terminated. Density Ne was estimated along the Rosetta trajectories around comet 67P. For this long-term study, we utilized the average Ne. The main neutral species present in the 67P coma are reported to be H2O, CO2, and CO (Hässig et al. 2015; Le Roy et al. 2015; Fougere et al.)