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Physical process in the coma of comet 67P derived from narrowband imaging of fragment species

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Abstract

During the rendezvous of the Rosetta spacecraft with comet 67P/Churyumov-Gerasimenko, the OSIRIS scientific cameras monitored the near-nucleus gas environment in various narrow-band filters, observing various fragment species. It turned out that the excitation processes in the innermost coma are significantly different from the overall coma, as observed from the ground [1]. In particular, some of the observed emissions of fragments (daughter molecules) are created by direct dissociation of parent molecules, and in those cases the spatial distribution of the emission directly maps the distribution of parent molecules. We investigate the evolution of the brightness and distribution of the emissions over time to improve our understanding of the underlying emission mechanisms and to derive the spatial distribution of H_2O and CO_2. The outcome will provide constraints on the homogeneity of the cometary nucleus.

1. Introduction

For many decades, the observation of fragment species in the visible spectral range has been a tool to study the gas coma of comets (e.g. [2]). The creation and destruction of those molecules through fluorescence and through collisions with water molecules is now well understood for some species (e.g. H_2O -> OH or HCN -> CN). A special case are the OI lines in the green and red spectral range that are known to be largely created by prompt emission after dissociation of parent molecules into an excited state of oxygen. Their distribution therefore maps that of their parent molecules.

When Rosetta spent more than 2 years at comet 67P, the Wide Angle Camera (WAC), one of the OSIRIS scientific cameras, observed the gas coma from the onset of detectable gas activity through perihelion until the end of mission at 3.8 AU outbound. WAC observations were performed in 7 narrow band filters, targeting emissions of the daughter molecules CS (created from CS_2), OH (created from H_2O), NH and NH_2 (the parent molecule of both is NH_3) CN (a daughter molecule of HCN), Na (created from dust or a sodium bearing molecule) and OI (a product of H_2O, CO_2 and O_2). While ground-based observations typically cover the coma at spatial scales of 10000s to 100000s of km with a resolution of a few 100 km, Rosetta was most of the time between 10 km and a few hundred km from the nucleus, providing a resolution of decimetre o metre scale, at a field of view of between less than 10 km and 100 km.

2. A new emission process: Prompt emission from electron impact dissociation

Gas emission from the OSIRIS narrow band filters was detected early on, and at substantially higher intensities than expected. As the corresponding gas production rates would have been unrealistic high (compared to measurements by other instruments on Rosetta, a new process acting in the inner coma had to be found to explain the observations. Indeed, *Bodewits et al.* [1] were able to explain most of the emissions with electron impact excitation by low energy electrons in the inner coma. Notably, the emissions in some of the filters were not from the species that were expected to be seen (see Table 1). Closer to the sun, generally the known processes took over in dominating the observed emissions.

Table 1: The emissions targeted by the 7 narrow band filters of the OSIRIS WAC, the processes known from ground-based observations at those wavelengths, and the additional processes detected by OSIRIS in the very inner coma (from ref. [1]). F = Fluorescence, PD = Photodissociation followed by prompt emission, EID = Electron Impact Dissociation followed by prompt emission, RS = Resonance Scattering. In brackets: the parent and daughter molecules involved in the emission.

Emission	**Known processes**	**Additional processes [1]**
CS 257 nm	F (CS_2, CS)	-
OH 308 nm	F (H_2O, OH) PD (H_2O,OH)?	EID (H_2O, OH)
NH 335 nm	F (NH_3, NH_2 NH)	EID (H_2O, OH^+)
CN 388 nm	F (HCN, CN)	EID (CO_2, CO_2^+)
NH_2 570 nm	F (NH_3, NH_2)	?
Na 589 nm	RS (dust or Na-bearing molecule, Na)	-
O I 630 nm	PD (H_2O, O)	EID (H_2O, O) EID (CO_2, O)

3. Nucleus homogeneity from gas emissions in the very inner coma

At large heliocentric distance the newly found processes listed in Table 1 dominate the emissions seen by OSIRIS. This allows to map both, the spatial distribution of H_2O (through prompt emission of OH and OH^+ after electron impact dissociation of H_2O), and that of CO_2 (through prompt emission of CO_2^+ after electron impact dissociation of CO_2). In this way we compare the spatial distribution of the two major ices of the nucleus through the gas immediately above it. We will present those distributions and their implications on the homogeneity of the cometary nucleus.

4. Conclusions

The Rosetta mission allows for the first time to monitor gas emissions directly at the cometary nucleus. In addition to observing the physical processes in the nucleus-coma interaction region, we can deduce the localized production of various molecules as a function of position on the nucleus, providing constraints on the homogeneity of the nucleus and on its evolution over time.

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References

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