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Diurnal and seasonal variations of gas emissions in the inner coma of comet 67P/Churyumov-Gerasimenko observed with OSIRIS/Rosetta

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Abstract

The European Rosetta mission spent more than two years orbiting the Jupiter family comet 67P/Churyumov-Gerasimenko. Such long duration allowed a very comprehensive analysis of the changes in the comet's activity along its orbit around the Sun.

The OSIRIS/Wide Angle Camera (WAC) [1] on board the spacecraft, was designed to study the gas coma around the comet nucleus. It was equipped with several narrow-band filters centered on the typical cometary emission bands of various gas species, in particular: OH (309.8 nm), NH (335.9 nm), CN (388.4 nm), NH_2 (572.1 nm) and OI (631.6 nm). For most of the mission timeline these filters were used to monitor the evolution of the production and spatial distribution of these gas species in the coma of comet 67P.

Several gas monitoring sequences were acquired with a well defined comet-spacecraft configuration (e.g. nadir pointing, phase angle below 100° to avoid straylight) employing the largest possible set of gas filters and spanning a period of time of about 14 hours, longer than one rotation period of the comet (12 h) allowing us to study diurnal variations. Our dataset incudes 32 gas sequences, going from January to September 2015, i.e. from 2.47 AU pre-perihelion, to 1.37 AU post-perihelion. After September 2015 the camera shutter had to be operated in a fast frame mode; since the data acquired aftwerwards needed a different reduction approach, they have been excluded from this analysis.

The filter bandpass includes both gas emission lines and the continuum reflected by the comet's dust. To create "pure" gas images, the continuum needs to be removed. Five multiband sequences have been used to study the continuum, almost evenly spanning the gas observation window. These sequences have been acquired typically with the NAC camera of OSIRIS intrument [1], equipped with medium and large band filters for nucleus and continuum analysis. For each epoch we used from 8 to 30 multiband data (cubes) to investigate the continuum spectral behavior depending on the rotation status of the comet. A typical dust spectral slope has been derived for each epoch, revealing a blue enhancement at smaller heliocentric distances. The dust spectral slope has been then interpolated for each gas observation epoch, and continuum removal factors have been derived, changing with heliocentric distance.

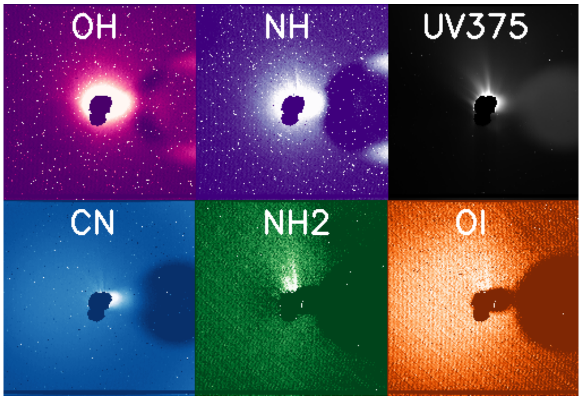

Figure 1: "Pure" gas images acquired by OSIRIS on 12/04/2015 showing the spatial distribution of gaseous species and UV375 continuum image for comparison.

The "pure" gas images (Fig. 1) reveal the spatial distribution of the fragment species being quite stable for a long period of time and confirm that the spatial distribution found by Bodewits et al. 2016 [2] for five of the considered epochs remained substantially steady with time. OH and NH fragments show an isotropic distribution, typical of fragment species coming from dissociation of other parent molecules. CN and OI show instead a two-component distribution throughout the dataset possibly connected to additional prompt emissions. NH_2 has a very small signal to noise ratio and its interpretaion is not straightforward.

The gas surface brightness is then converted into column density for each gas species using specific fluorescence efficiency factors [4, 3] interpolated for the heliocentric distance and velocity of the comet at each epoch.

An "extraction zone" was defined between 1 and 3 km from the nucleus limb in the sunward direction between 10 and 2 o'clock in order to exclude straylight, ghosts and other instrumental effects [5] from the analysis. For each epoch we therefore obtained gas light curves for each species and consequently a long-term variation behavior.

Results will be presented on the gas diurnal light curves and on the long-term variations such as the dependence and correlation with time, heliocentric distance, range, phase angle and sub-solar point. Gas ratios are studied searching for evidence of any compositional change with time and orbital evolution. We will search for connections between particular "active zones" on the nucleus surface using the projection of the comet shape model (SHAP5-v1.5) and the relevant NAIF Spice Kernels and IDL toolkit. Correlations with dust outbursts and jets are also investigated. This study will be helpful in connecting ground based observations of 67P with Rosetta in situ observations.

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