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Summer outbursts in the coma of 67P/Churyumov-Gerasimenko as observed by VIRTIS-M

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1- Introduction

The Rosetta/ESA spacecraft followed the comet 67P/Churyumov-Gerasimenko (hereafter 67P/CG) from 2014 August (3.6 au pre-perihelion) to 2016 September (3.6 au post-perihelion). This offered a unique opportunity to follow closely a comet during the most active part of its nucleus. Onboard Rosetta, the Visual Infrared and Thermal Imaging Spectrometer (VIRTIS-M, Coradini et al. 2007) in the spectral range 0.25 to 5µm, acquired a relevant amount of dust coma measurements. In this work, we present an analysis of the outbursts observed by VIRTIS-M for the dates of August 10, September 13 and 14 2015, when the comet was at heliocentric distances of -1.2 AU (inbound) to 1.3 AU (outbound), 2 day before and one month after the perihelion passage respectively. The dust properties of the outbursts are discussed in terms of spatial distribution, temporal evolution and surface location. We also analyze dust physical properties such as total dust mass loss, reflectance and color.

2- Outburst properties

The outbursts on 67P/CG occur at typically rate of one every 2.4 cometary rotation in the daylight side of the nucleus (Vincent at al. 2016). They are characterized by a sudden and short increase of the dust emission, from localized areas with variable degree of collimation, followed by a sweet decrease of activity. The lifetime is between 5 and 15 minutes and the corresponding radiance at 0.55 µm is typically of the order of 10^{-2} – 1 Watt/m^2/str/µm, i.e. 10-20 times larger than the surrounding coma. VIRTIS-M identified 2 main dust plumes morphologies associated to these events: a narrow jet (September 13, Fig.1) and a broad plumes (August 10 and September 14, Fig.2). On Sept. 13 and 14 the comet produced 3 and 2 consecutive outbursts, respectively.

On September 13 the spatial and temporal distribution of the dust indicates a complex pattern for each event showing internal structures (Fig.1, first panel).

We analysed the map locations of these events and we found that broad emission are likely from the Imhotep region and the collimated ones originate from the neck region. It seems that the spatial distribution of outbursts locations on the nucleus correlates well with local topography.

In Fig.3 we report a color image corresponding to the 2015 September 13 (upper panel) and 14 (lower panel) events. We found clear evidence of different colour values in the ouburst with respect to the surrounding coma. In the range of 0.45-0.75 µm, the spectral slope shows a lower value for the outburst material in the range 10-12 % per 100 nm, than the values in the background, in the range 15-16 % per 100 nm (Fig.3 upper panel). A peculiar case is the September 14 large outburst. In the color map (Fig.3 lower panel), the front of the outburst is bluer than the rest of the coma, with values of 4.0-7.0 %/100nm. The color corresponding to peak of the maximum intensity is around 7 %/100nm, while at smaller levels of the radiance it is of the order of 10.0 – 14.0 %/100nm. The same color behavior has been observed by VIRTIS-H on the IR channel. Bockelee-Morvan et al. (2017, submitted) found that the evolution of the color in the IR channel reaches the extreme value of -10 %/100nm at the peak of intensity, returning to the pre-outburst value of about 2.5 %/100nm. The color variation can be explained as a change of size distribution, with the front part dominated by smallest particles which are accelerated faster from the gas drag. This implies that we observed dust with different physical characteristics both in the structures and in the coma.

The comparison between IR (VIRTIS-H) and VIS (VIRTISM) observations allows to derive the projected velocity of the small dust grain obtaining 23 -40 m/s.

It is also possible to estimate the total mass loss in the outburst, by converting the radiance over an image to a dust cross section, and then to mass assuming a dust size distribution with a power law index of -3. For September 14 large event we estimated a total ejected dust mass of few tens tons as found by Vincent et al. 2016.

Further analysis will be presented during the congress.

References

[1] Coradini, A., et al., 2007, SSRv, 128, 529

[2] Bockelee-Morvan et al. 2017, submitted to MNRAS

[3] Vincent J.-B., et al., 2016, MNRAS , 462, S184.

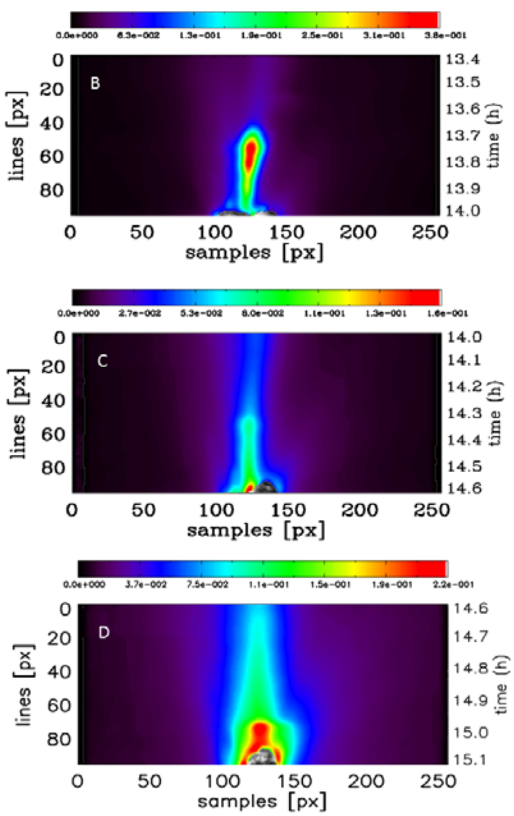

Fig. 1. The distribution of dust radiance at 0.55 µm. for the images acquired on 2015 September 13, showing the nucleus, the surrounding coma and outburst (collimated jet). Color bars have units of Watt/m2/str/µm.

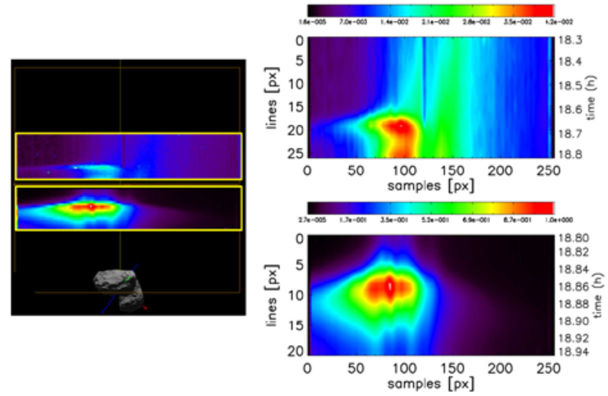

Fig. 2. Spatial distribution of dust continuum at 0.5µm for 2015 September 14. The image on the left shows the configuration of the nucleus of the comet with respect to the VIRTIS-M frames (yellow rectangle). The images on the right show the spatial distribution of dust radiance at 0.5µm.

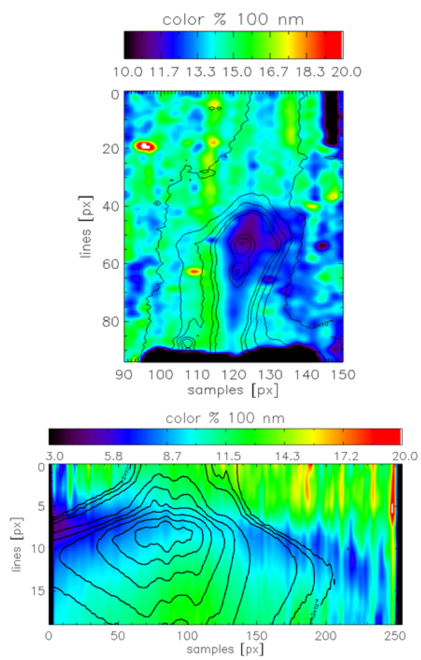

Fig.3 Color image corresponding to the September 13 (upper panel) and 14 (lower panel) 2015. The black contour levels are the radiance at 0.55 µm.