The dust and gas analysis at 67P/Churyumov-Gerasimenko sheds light on cometary activity.

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Introduction: Cometary outbursts are well-known and they offer a valuable window into the composition of comet nuclei with their forceful ejection of dust and gas that reveals interior components of the comet. Understanding how different types of outbursts influence the observed dust properties and volatile abundances is necessary to better interpret what signatures can be attributed to primordial composition and what features are the result of processing. As such, it is an important task best undertaken with a multi-instrument approach. During the period between July and November 2015, the Rosetta spacecraft had monitored the inner coma of comet 67P/Churyumov-Gerasimenko (67P/CG). This period encompassed the passage at perihelion (August 2015) resulting in the most active part of its orbit. The Visible InfraRed the Thermal Imaging Spectrometer (VIRTIS) [1] and the ALICE ultraviolet spectrograph, [2] onboard Rosetta observed and detected a series of outburst. Previous Alice observations of outbursts have revealed a range of compositions and emission processes within these periods of increased activity. H2O, CO2, CO, and O2 were all indirectly observed within outbursts via emission from the daughter products H, C, and O , identified in the spectra as the first three members of the H I Lyman series, OI multiplets at 1152, 1304, and 1356 Å, and weak multiplets of C I at 1561 and 1657 Å [3]. VIRTIS detected and characterized the dust properties of the outburst in terms of light curve, color, and dust mass loss in the VIS and IR wavelength range. The aim of this work is to take advantage of the capabilities of two instruments to analyze the dust and gas coma trends during these transient events.

Gas component. Alice outburst spectra show the transient events characterised by a different CO2/H2O and O2/H2O ratio as determined from spectral modeling and different observed O I 1356/O I 1304 Å ratio. In cases where dissociative electron impact excitation on O2 or CO2 is dominant, we would expect the O I 1356/O I 1304 Å ratio greaten than 1, while if dissociative electron impact occurs on H2O, this value would be less than 1 [5, 10]. Elevated CO2 content could indicate a more pristine surface origin (i.e., fracture deepening) and the subsequent activity was sustained for over two hours.

Dust component. The VIRTIS observations show two kind of outbursts. The first type is characterize by a strong color gradient values in the dust continuum with respect to the surrounding coma and the second type doesn't show colour difference [4,5,7]. The outburst colour sequence in the VIS and IR show a colour gradient pattern which seems correlated to the intensity of the dust radiance within the outburst [7,8]. The first type of outburst shows a VIS colour behaviour reaching the bluer values of 6±1.4 % /100 nm and returning to the pre-outburst value of about 14 % /100 nm [4,5]. The IR continuum emission is also characterised by high colour temperatures of about 600 K and a bolometric albedo of 0.6 [5]. Colour temperatures of 600 K thus reveals the presence of very small grains (less than 100 nm) in the outburst material. The bright grains in the ejecta could be silicate grains, implying the thermal degradation of the carbonaceous material, or icy grains. The rapid increase in radiance at the start of an outburst event is not due primarily to an increase in the number of existing dust particles, but rather to the release of small and bright silicate or icy particles with a high geometric albedo and a filling factor between 1.3 and 5.0 % [4,5]. For the second type of outburst, we found no clear evidence of different reddening values in the dust continuum with respect to the surrounding coma. The reason is probably that this is a faint outburst and the signal from the background coma dominates, so the colour of the outburst is not measurable. The VIS dust color is around 13.1% /100 nm [4,5,7].

Preliminary Results: The outburst observations show that mixed gas and dust outbursts can exhibit different spectral signatures representative of their initiating mechanisms, with outbursts showing indicators of a cliff collapse origin or showing fresh volatiles being exposed via a deepening fracture. Preliminary analysis shows that some cometary activity observed after outbursts has a moderate CO2/H2O ratio, evidence that O2 may have initiated the outburst and exposed new volatile-richmaterial. This analysis opens up the possibility of remote spectral classification of cometary activity with future work.

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