

The Rosetta spacecraft recorded the eruption of jets of dust on 67P/Churyumov-Gerasimenko

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The impressive jets of dust that comets emit into space during their journey around the Sun are not driven solely by the sublimation of frozen water. In some cases further processes augment the outbreaks. Possible scenarios include the release of pressurized gas stored below the surface or the conversion of one kind of frozen water into an energetically more favourable one. These are the findings of a study headed by scientists of the Max Planck Institute for Solar System Research who examined a dust jet from Rosetta's comet 67P/Churyumov-Gerasimenko that occurred last year.

When the Sun rose over the Imhotep region of Rosetta's comet on July 3, 2016, everything was just right: As the surface warmed and began to emit [dust](#) into space, Rosetta's trajectory led the probe right through the cloud. At the same time, the view of the scientific camera system OSIRIS coincidentally focused precisely on the surface region of the comet from which the fountain originated. A total of five instruments on board the probe were able to document the outburst in the following hours.

"This was an amazing stroke of luck. It is impossible to plan something like this," says Jessica Agarwal of the MPS, head of the study. After all, outbursts of dust usually appear without any prior warning. Therefore, most events like this one witnessed by Rosetta during its more than two-year stay at the comet, could only be recorded by a single instrument

from afar. In the rare cases in which Rosetta serendipitously flew through the dust jet, images of the crucial spot on the comet's surface are missing. "From the extensive measurement data of July 3, 2016, we were able to reconstruct the progress and the characteristics of the outburst as detailed as never before," says Agarwal.

The two in-situ instruments GIADA (Grain Impact Analyzer and Dust Accumulator) and COSIMA (Cometary Secondary Ion Mass Analyzer) captured individual dust particles from the jet and were able to determine velocities, sizes and average densities of the particles. "This is the first time that COSIMA has been able to help characterize a specific dust jet," explains Sihane Merouane from MPS, member of the COSIMA team. Because the instrument often collects particles for several weeks, it is difficult to assign them to one particular event. The COSIMA data suggest that the particles from the jet break more easily than the otherwise captured cometary material. "They must either be very fast or relatively loosely built," says MPS researcher Martin Hilchenbach, Principal Investigator of the COSIMA team.

In addition, the spectrograph Alice was able to track the increase in brightness due to the dust outburst and detected tiny ice particles in the cloud. Even one of the star sensors from Rosetta, which serve to determine the spacecraft's position in space, contributed a piece to the puzzle: Shortly after the outburst began, the star tracker recorded an increase in the radiation intensity from the cometary coma and recorded how this developed over the next hours.

"The unique aspect about the event of 3 July, 2016 are the high-resolution images of the surface," says MPS-scientist Holger Sierks, OSIRIS Principal Investigator. The researchers made out a circular area of about ten meters in diameter within a depression as the starting point of the jet. As the analysis of the OSIRIS data show, this area contains frozen water at the surface.

In general, scientists assume that frozen gases on a comet's surface, such as water, are responsible for dust production. Under the influence of the Sun, these substances pass directly into the gaseous state; the gas streaming into space entrains dust particles with it and thus produces the visible jets. Often these occur shortly after sunrise.

However, the current study shows that this process alone cannot explain the event of July 3, 2016. With a dust production of approximately 18 kilograms per second, the jet is a lot "dustier" than conventional models predict. "An additional energetic process must be at play – energy must have been released from beneath the surface to support the plume," says Agarwal.

It is conceivable, for example, that under the surface of the comet there are cavities filled with compressed gas. Upon sunrise, the radiation begins to warm the overlying surface, cracks develop and the gas escapes. According to another theory, deposits of amorphous ice beneath the surface play a decisive role. In this type of [frozen water](#), the individual molecules are not aligned in a lattice-like structure, as is customary in the case of crystalline ice, but arranged in a far more disorderly fashion. Since the crystalline state is energetically more favorable, energy is released during the transition from amorphous to crystalline ice. Energy input through sunlight can start this transformation. Exactly which process took place on 3 July of last year is still unclear.

More information: Evidence of sub-surface energy storage in comet 67P from the outburst of 3 July 2016,
Monthly Notices of the Royal Astronomical Society, 24 October 2017

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