Comet's firework display ahead of perihelion

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A short-lived outburst from Comet 67P/Churyumov–Gerasimenko was captured by Rosetta's OSIRIS narrow-angle camera on 29 July 2015. The image at left was taken at 13:06 GMT and does not show any visible signs of the jet. It is very strong in the middle image captured at 13:24 GMT. Residual traces of activity are only very faintly visible in the final image taken at 13:42 GMT. The images were taken from a distance of 186 km from the centre of the comet. The jet is estimated to have a minimum speed of 10 m/s and originates from a location on the comet's neck, in the rugged Anuket region. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

In the approach to perihelion over the past few weeks, Rosetta has been witnessing growing activity from Comet 67P/Churyumov–Gerasimenko, with one dramatic outburst event proving so powerful that it even pushed away the incoming solar wind.

The comet reaches perihelion on Thursday, the moment in its 6.5-year orbit when it is closest to the Sun. In recent months, the increasing solar energy has been warming the comet's frozen ices, turning them to gas, which pours out into space, dragging dust along with it.

The period around perihelion is scientifically very important, as the intensity of the sunlight increases and parts of the comet previously cast in years of darkness are flooded with sunlight.

Although the comet's general activity is expected to peak in the weeks following perihelion, much as the hottest days of summer usually come after the longest days, sudden and unpredictable outbursts can occur at any time – as already seen earlier in the mission.

On 29 July, Rosetta observed the most dramatic outburst yet, registered by several of its instruments from their vantage point 186 km from the comet. They imaged the outburst erupting from the nucleus, witnessed a change in the structure and composition of the gaseous coma environment surrounding Rosetta, and detected increased levels of dust impacts.

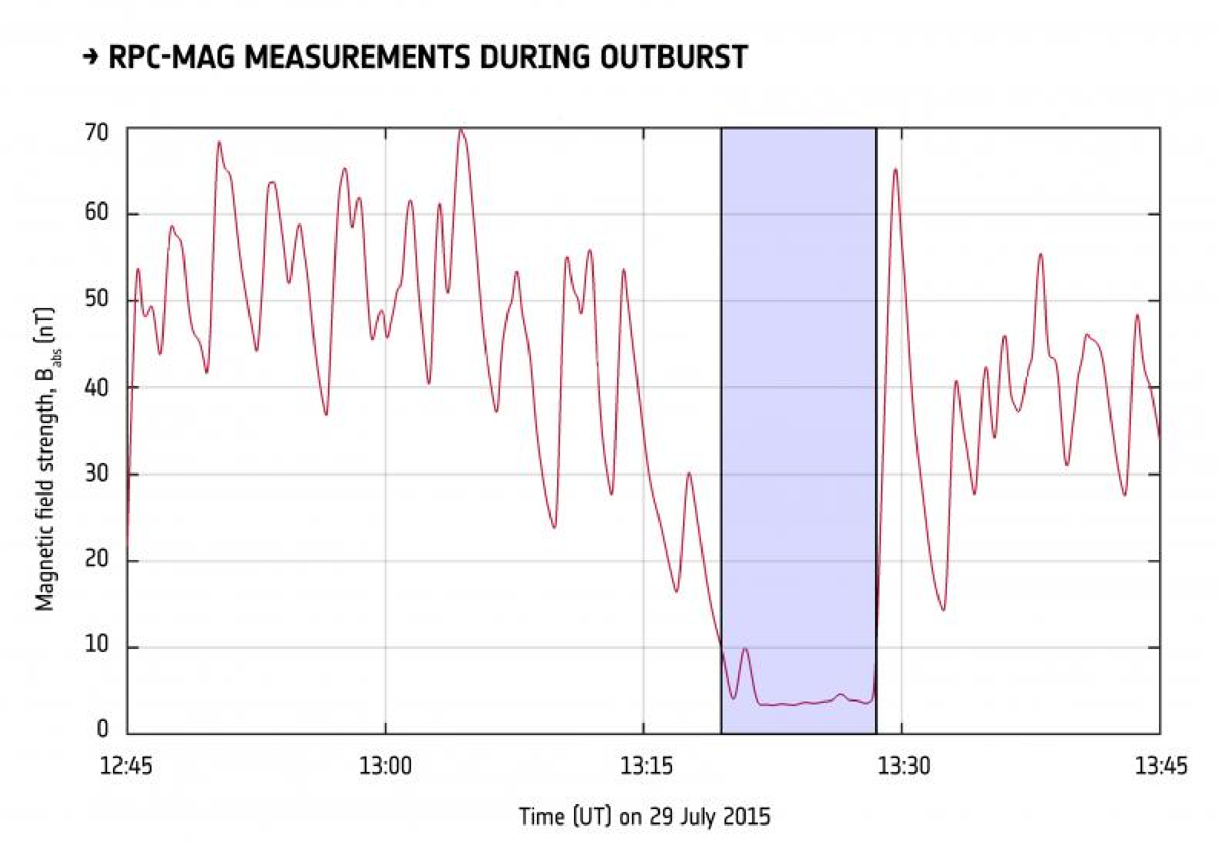
Perhaps most surprisingly, Rosetta found that the outburst had pushed away the solar wind magnetic field from around the nucleus.

A sequence of images taken by Rosetta's scientific camera OSIRIS show the sudden onset of a well-defined jet-like feature emerging from the side of the comet's neck, in the Anuket region. It was first seen in an image taken at 13:24 GMT, but not in an image taken 18 minutes earlier, and has faded significantly in an image captured 18 minutes later. The camera team estimates the material in the jet to be travelling at 10 m/s at least, and perhaps much faster.

"This is the brightest jet we've seen so far," comments Carsten Güttler, OSIRIS team member at the Max Planck Institute for Solar System Research in Göttingen, Germany.

"Usually, the jets are quite faint compared to the nucleus and we need to stretch the contrast of the images to make them visible – but this one is brighter than the nucleus."

Soon afterwards, the comet pressure sensor of ROSINA detected clear indications of changes in the structure of the coma, while its mass spectrometer recorded changes in the composition of outpouring gases.



The decrease in magnetic field strength measured by Rosetta's RPC-MAG instrument during the outburst event on 29 July 2015. This is the first time a 'diamagnetic cavity' has been detected at Comet 67P/Churyumov–Gerasimenko and is thought to be caused by an outburst of gas temporarily increasing the gas flux in the comet's coma, and pushing the pressure-balance boundary between it and incoming solar wind farther from the nucleus than expected under 'normal' levels of activity. Credit: ESA/Rosetta/RPC/IGEP/IC

For example, compared to measurements made two days earlier, the amount of carbon dioxide increased by a factor of two, methane by four, and hydrogen sulphide by seven, while the amount of water stayed almost constant.

"This first 'quick look' at our measurements after the outburst is fascinating," says Kathrin Altwegg, ROSINA principal investigator at the University of Bern. "We also see hints of heavy organic material after the outburst that might be related to the ejected dust.

"But while it is tempting to think that we are detecting material that may have been freed from beneath the comet's surface, it is too early to say for certain that this is the case."

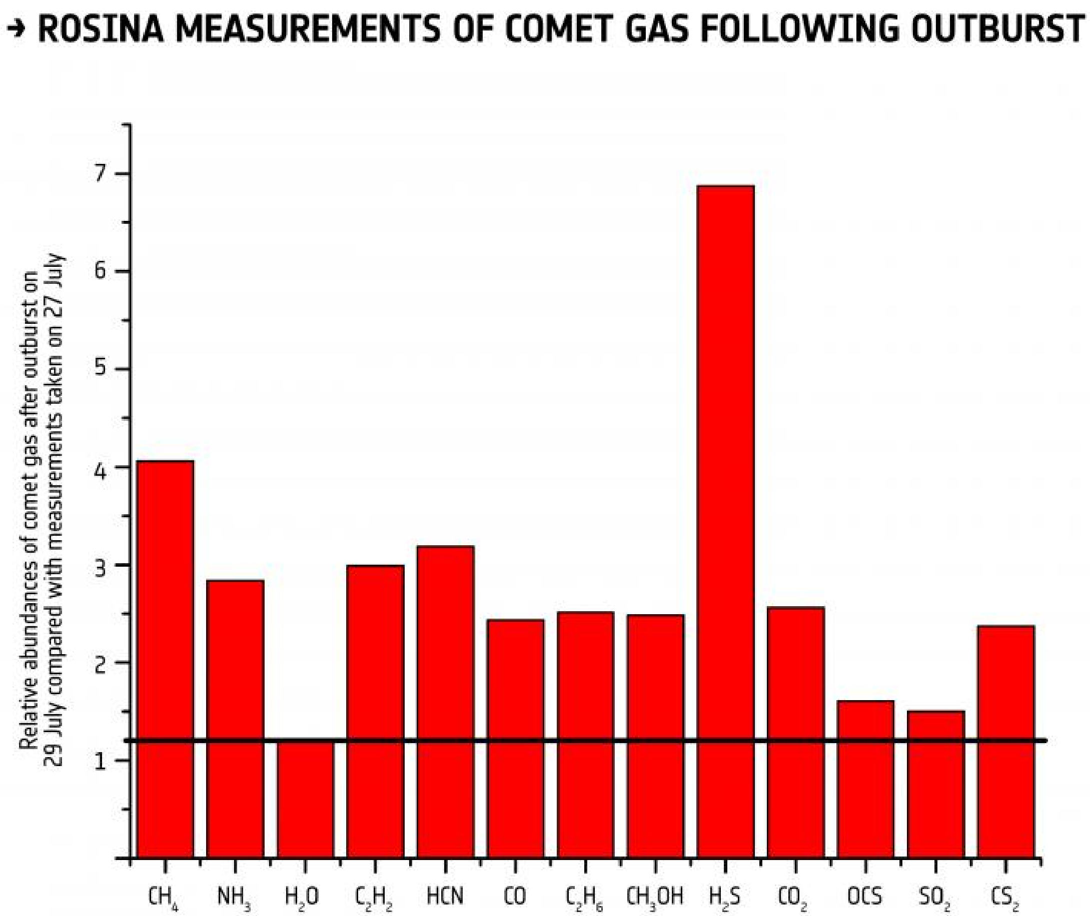
Meanwhile, about 14 hours after the outburst, GIADA was detecting dust hits at rates of 30 per day, compared with just 1–3 per day earlier in July. A peak of 70 hits was recorded in one 4-hour period on 1 August, indicating that the outburst continued to have a significant effect on the dust environment for the following few days.

"It was not only the abundance of the particles, but also their speeds measured by GIADA that told us something 'different' was happening: the average particle speed increased from 8 m/s to about 20 m/s, with peaks at 30 m/s – it was quite a dust party!" says Alessandra Rotundi, principal investigator at the 'Parthenope' University of Naples, Italy.

Perhaps the most striking result is that the outburst was so intense that it actually managed to push the solar wind away from the nucleus for a few minutes – a unique observation made by the Rosetta Plasma Consortium's magnetometer.

The solar wind is the constant stream of electrically charged particles that flows out from the Sun, carrying its magnetic field out into the Solar System. Earlier measurements made by Rosetta and Philae had already shown that the comet is not magnetised, so the only source for the magnetic field measured around it is the solar wind.

But it doesn't flow past unimpeded. Because the comet is spewing out gas, the incoming solar wind is slowed to a standstill where it encounters that gas and a pressure balance is reached.



During an outburst of gas and dust from Comet 67P/Churyumov–Gerasimenko on 29 July 2015, Rosetta's ROSINA instrument detected a change in the composition of gases compared with previous days. The graph shows the relative abundances of various gases after the outburst, compared with the measurements two days earlier. For example, the amount of carbon dioxide (CO_2) increased by a factor of two, methane (CH_4) by four, and hydrogen sulphide (H_2S) by seven, while the amount of water (indicated by the horizontal black line) stayed almost constant.

"The solar wind magnetic field starts to pile up, like a traffic jam, and eventually stops moving towards the comet nucleus, creating a magnetic field-free region on the Sun-facing side of the comet called a 'diamagnetic cavity'," explains Charlotte Götz, magnetometer team member at the Institute for Geophysics and extraterrestrial Physics in Braunschweig, Germany.

Diamagnetic cavities provide fundamental information on how a comet interacts with the solar wind, but the only previous detection of one associated with a comet was made at about 4000 km from Comet Halley as ESA's Giotto flew past in 1986.

Rosetta's comet is much less active than Halley, so scientists expected to find a much smaller cavity around it, up to a few tens of kilometres at most, and prior to 29 July, had not observed any sign of one.

But, following the outburst on that day, the magnetometer detected a diamagnetic cavity extending out at least 186 km from the nucleus. This was likely created by the outburst of gas, which increased the neutral gas flux in the comet's coma, forcing the solar wind to 'stop' further away from the comet and thus pushing the cavity boundary outwards beyond where Rosetta was flying at the time.

This image, taken on 12 April 2015 by the OSIRIS narrow-angle camera, identifies the source region of the outburst from Comet 67P/Churyumov–Gerasimenko observed by Rosetta's instruments on 29 July. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

"Finding a magnetic field-free region anyway in the Solar System is really hard, but here we've had it served to us on a silver platter – this is a really exciting result for us," adds Charlotte.

"We've been moving Rosetta out to distances of up to 300 km in recent weeks to avoid problems with navigation caused by dust, and we had considered that the diamagnetic cavity was out of our grasp for the time being. But it seems that the comet has helped us by bringing the cavity to Rosetta," says Matt Taylor, Rosetta Project Scientist.

"This is a fantastic multi-instrument event which will take time to analyse, but highlights the exciting times we're experiencing at the comet in this 'hot' perihelion phase."

Provided by European Space Agency

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