Enceladus jets: Surprises in starlight

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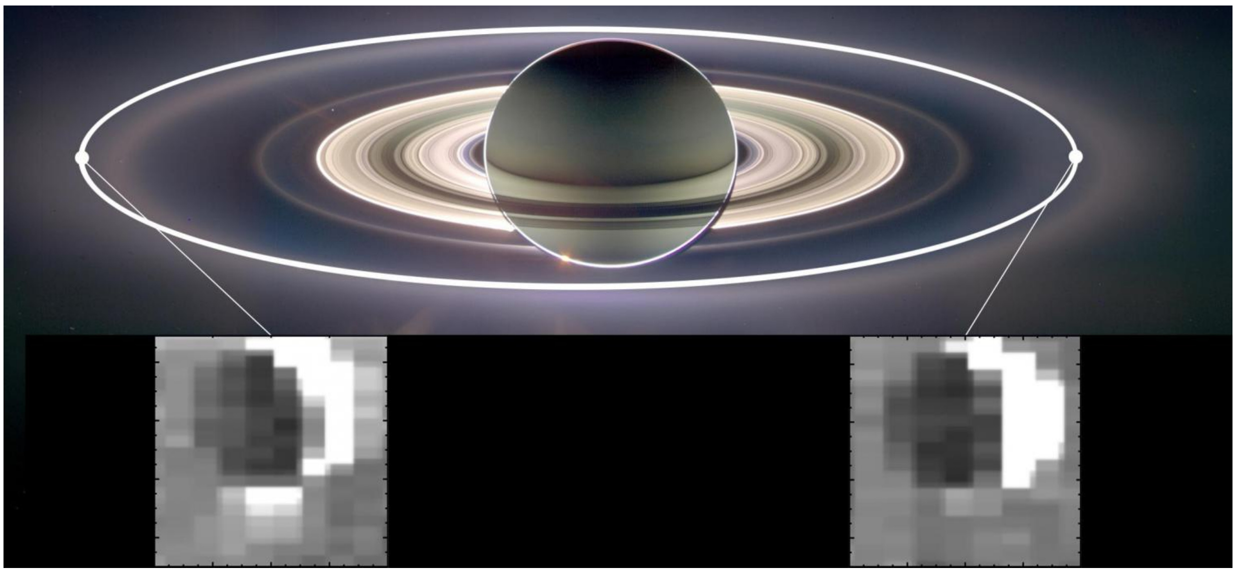


This set of images from NASA's Cassini mission shows how the gravitational pull of Saturn affects the amount of spray coming from jets at the active moon Enceladus. Enceladus has the most spray when it is farthest away from Saturn in its orbit (inset image on the left) and the least spray when it is closest to Saturn (inset image on the right). Water ice and organic particles gush out of fissures known as "tiger stripes" at Enceladus' south pole. Scientists think the fissures are squeezed shut when the moon is feeling the greatest force of Saturn's gravity. They theorize the reduction of that gravity allows the fissures to open and release the spray. Enceladus' orbit is slightly closer to Saturn on one side than the other. A simplified version of that orbit is shown as a white oval. Scientists correlate the brightness of the Enceladus plume to the amount of solid material being ejected because the fine grains of water ice in the plume are very bright when lit from behind. Between the dimmest and brightest images, they detected a change of about three to four times in brightness, approximately the same as moving from a dim hallway to a brightly lit office. This analysis is the first clear finding that shows the jets at Enceladus vary in a predictable manner. The background image is a mosaic made from data obtained by Cassini's imaging science subsystem in 2006. The inset image on the left was obtained on Oct. 1, 2011. The inset image on the right was obtained on Jan. 30, 2011. Credit: NASA/JPL-Caltech/University of Arizona/Cornell/SSI

During a recent stargazing session, NASA's Cassini spacecraft watched a bright star pass behind the plume of gas and dust that spews from Saturn's icy moon Enceladus. At first, the data from that observation had scientists scratching their heads. What they saw didn't fit their predictions.

The observation has led to a surprising new clue about the remarkable geologic activity on Enceladus: It appears that at least some of the narrow jets that erupt from the moon's surface blast with increased fury when the moon is farther from Saturn in its orbit.

Exactly how or why that's happening is far from clear, but the observation gives theorists new possibilities to ponder about the twists and turns in the "plumbing" under the moon's frozen surface. Scientists are eager for such clues because, beneath its frozen shell of ice, Enceladus is an ocean world that might have the ingredients for life.

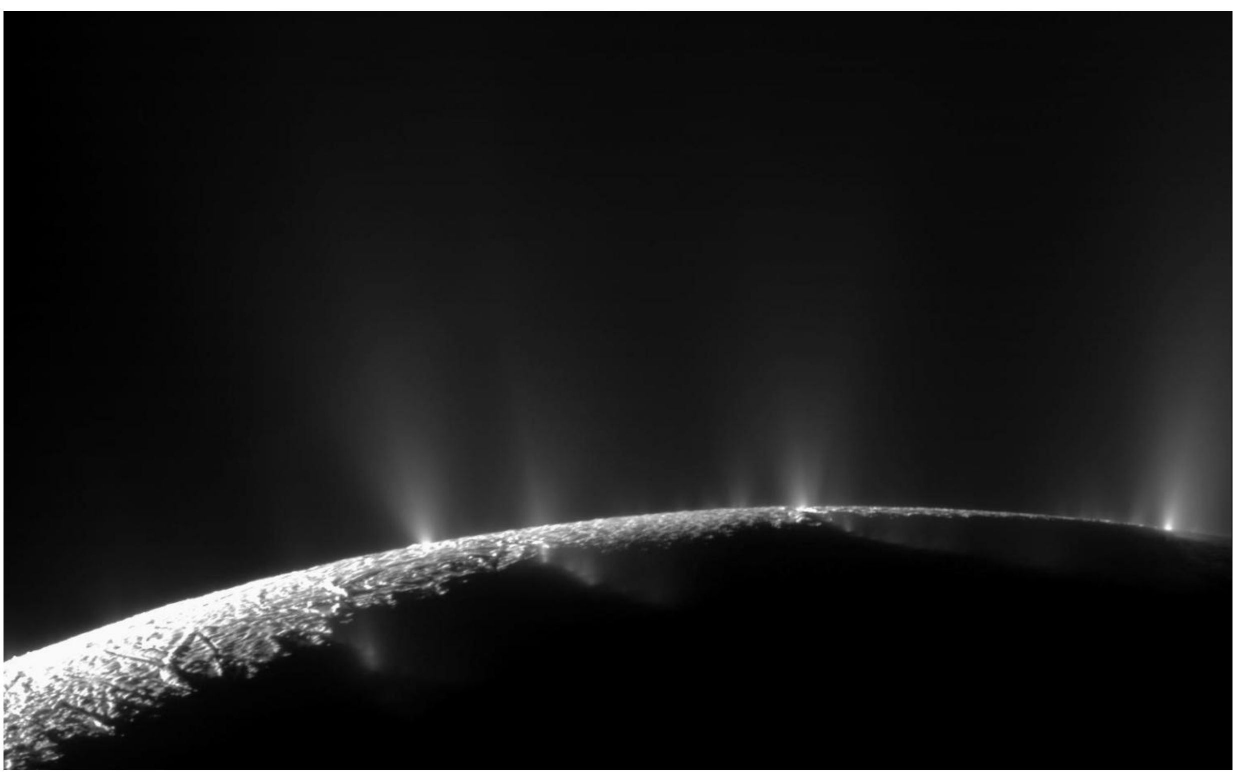
It's a Gas, Man

During its first few years after arriving at Saturn in 2004, Cassini discovered that Enceladus continuously spews a broad plume of gas and dust-sized ice grains from the region around its south pole. This plume extends hundreds of miles into space, and is several times the width of the small moon itself. Scores of narrow jets burst from the surface along great fractures known as "tiger stripes" and contribute to the plume. The activity is understood to originate from the moon's subsurface ocean of salty liquid water, which is venting into space.

Cassini has shown that more than 90 percent of the material in the plume is water vapor. This gas lofts dust grains into space where sunlight scatters off them, making them visible to the spacecraft's cameras. Cassini has even collected some of the particles being blasted off Enceladus and analyzed their composition.

Not the Obvious Explanation

Previous Cassini observations saw the eruptions spraying three times as much icy dust into space when Enceladus neared the farthest point in its elliptical orbit around Saturn. But until now, scientists hadn't had an opportunity to see if the gas part of the eruptions—which makes up the majority of the plume's mass—also increased at this time.



Dramatic plumes, both large and small, spray water ice out from many locations along the famed "tiger stripes" near the south pole of Saturn's moon Enceladus. The tiger stripes are fissures that spray icy particles, water vapor and organic compounds. More than 30 individual jets of different sizes can be seen in this image and more than 20 of them had not been identified before. At least one jet spouting prominently in previous images now appears less powerful. This mosaic was created from two high-resolution images that were captured by the narrow-angle camera when NASA's Cassini spacecraft flew past Enceladus and through the jets on Nov. 21, 2009. (For other images captured during the same flyby, see PIA11686 and PIA11687). Imaging the jets over time will allow Cassini scientists to study the consistency of their activity. The south pole of the moon lies near the limb in the top left quadrant of the mosaic, near the large jet that is second from left. Lit terrain seen here is on the leading hemisphere of Enceladus (504 kilometers, 313 miles across). Credit: NASA/JPL/Space Science Institute

So on March 11, 2016, during a carefully planned observing run, Cassini set its gaze on Epsilon Orionis, the central star in Orion's belt. At the appointed time, Enceladus and its erupting plume glided in front of the star. Cassini's ultraviolet imaging spectrometer (or UVIS) measured how water vapor in the plume dimmed the star's ultraviolet light, revealing how much gas the plume contained. Since lots of extra dust appears at this point in the moon's orbit, scientists expected to measure a lot more gas in the plume, pushing the dust into space.

But instead of the expected huge increase in water vapor output, the UVIS instrument only saw a slight bump—just a 20 percent increase in the total amount of gas.

Cassini scientist Candy Hansen quickly set to work trying to figure out what might be going on. Hansen, a UVIS team member at the Planetary

Science Institute in Tucson, led the planning of the observation. "We went after the most obvious explanation first, but the data told us we needed to look deeper," she said. As it turned out, looking deeper meant paying attention to what was happening closer to the moon's surface.

Hansen and her colleagues focused their attention on one jet known informally as "Baghdad I." The researchers found that while the amount of gas in the overall plume didn't change much, this particular jet was four times more active than at other times in Enceladus' orbit. Instead of supplying just 2 percent of the plume's total water vapor, as Cassini previously observed, it was now supplying 8 percent of the plume's gas.

Call a Plumber

This insight revealed something subtle, but important, according to Larry Esposito, UVIS team lead at the University of Colorado at Boulder. "We had thought the amount of water vapor in the overall plume, across the whole south polar area, was being strongly affected by tidal forces from Saturn. Instead we find that the small-scale jets are what's changing." This increase in the jets' activity is what causes more icy dust grains to be lofted into space, where Cassini's cameras can see them, Esposito said.

The new observations provide helpful constraints on what could be going on with the underground plumbing—cracks and fissures through which water from the moon's potentially habitable subsurface ocean is making its way into space.

With the new Cassini data, Hansen is ready to toss the ball to the theoreticians. "Since we can only see what's going on above the surface, at the end of the day, it's up to the modelers to take this data and figure out what's going on underground."