Snowblower on Enceladus: Scientists discover how ice jets on the moon feed Saturn's E ring

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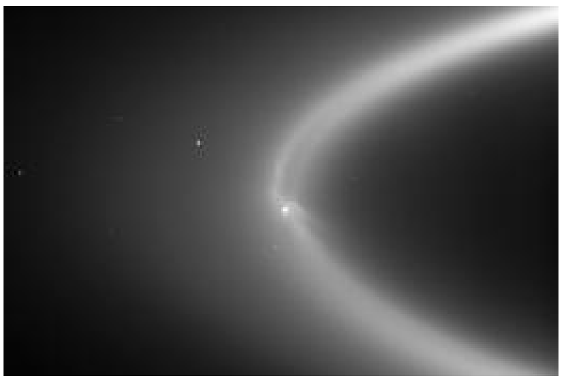

Thin strips of bright, icy material stretch across thousands of kilometres from the ice jets at the South Pole of the Enceladus in Saturn's E Ring. This back lit image in visible light was taken by the wide angle camera of the Cassini spacecraft from a distance of 2.1 million kilometres. Image: NASA/JPL/Space Science Institute

(PhysOrg.com) -- Cassini's nose dives through Saturn's E ring have yielded insights on the give and take of ice particles between Enceladus and the ring. Some of the moon's jets are successful in shooting ice grains far enough to become part of the E ring. But even the ice grains that make it to the E ring tend to be recaptured by Enceladus within a few orbits as the moon moves around Saturn.

This was discovered by scientists of the Max Planck Institutes for

Nuclear Physics using a dust detector on board of the Cassini spacecraft of NASA/ESA. To obtain these insights, they compared model data with data measured by the spacecraft (*Icarus* 206, 446-457, 2010).

Cassini's discovery of a plume coming from Enceladus was a major finding in planetary science; not only is this tiny moon curiously warm and active, the plume's water ice and vapour ejecta form the E ring and influence the entire Saturn system. The Cassini team has innovated ways to observe the plume and capture particles, pushing the spacecraft beyond its original purposes. They have been rewarded with new clues about this unusual moon and its far-reaching impacts.

The tack of Cassini's recent passes from the top to the bottom of the E ring has allowed observations of the vertical extent and structure of the ring. Cassini dust analyzer measurements, in particular, have provided unexpected details about how the ring is supplied with material, including the particle output and launching power of individual plume jets on Enceladus, according to Sascha Kempf of the Max Planck Institute for Nuclear Physics in Heidelberg. Kempf is the lead author of a paper reporting the results in the scientific journal, Icarus. The work relies on new models and simulations based on dust analyzer measurements of the E ring.

The authors say some plume jets are stronger than others, and the properties of the ice grains they produce may vary significantly from jet to jet. Most of the particles launched from the vents are gathered up by Enceladus within about two orbits. Particles that escape early capture might remain in the ring for an estimated 50 to 400 years.

When their instrument flew nearly vertically through the E ring, the scientists found what they expected, a smooth, Gaussian, or bell-curve distribution of particles like that found in Jupiter's gossamer ring, with particles congregating in the middle and thinning out at the ring's boundaries. Some unexpected spikes in the data were attributed to normal statistical fluctuations in the distribution of the particles.

On closer examination, however, the spikes in the ring's vertical profile were found to mirror the particle output of individual jets on Enceladus. The scientists found the activity of each jet is reflected in the vertical structure of the ring. The spikes reveal that some vents shoot out more material than others.

The ejecta from each vent could be identified even far away from Enceladus, the team reported. By tracing the trajectories of ice particles back to their sources, they determined, for example, that the Cairo Sulcus jet efficiently launches ice grains into the E ring, while fewer particles from Bagdad Sulcus make it that far. The simulations show that bigger particles, those larger than 0.7 microns, can only escape to the E ring if their initial speeds significantly exceed the escape speed of 207 meters per second (680 feet per second) - the escape velocity of the Enceladus surface.

The new model also shows that ice grains from Enceladus' frosty plume powders part, but not all of the moon with fresh ice, and points out the location and extent of plume material deposits. Independent of their size, the particles of the plume "snowfall" mostly land around the vents in the south polar tiger stripe region at a rate of about 0.5 millimeters (0.02 inches) per year. In general, particle fallout is restricted to this area, Kempf said. Earlier Cassini visible and infrared measurements indicated the size of water ice particles increased in tectonically altered areas beyond the tiger stripes. But the new model from dust analyzer measurements shows the largest water ice particles on the ground are closest to the tiger stripes and taper off in size beyond that region.

The surface distribution of particles of different sizes could be due to a variety of processes including plume ejecta, strikes of the ice surface by micrometeorites or weathering. There may be other processes that determine the grain sizes in the south polar terrain. Small ice grains might be recrystallized or become compacted, possibly in response to local heating near the vents.

The scientists found that Saturn's magnetic field also plays a role in determining how far a plume particle flies. The planet's magnetic field lines sweep past Enceladus and can carry away small ice grains that are more sensitive to the force of electro-magnetism. Larger, more massive particles are more susceptible to gravity and tend to fall back onto Enceladus.

Smaller particles snatched away by Saturn's magnetic field can make a more lasting escape from Enceladus. If these particles are not recaptured in a collision with Enceladus, they go on to become part of the water group ions that dominate Saturn's magnetosphere.

The research addresses a specific scientific goal of the Cassini mission - to discover the diverse interactions between Saturn's magnetosphere, the moons and the rings. Future measurements made during other near-vertical passes through the ring may help gauge other jet characteristics, including any variations in their activity, the scientists said. They propose that variation in the colours of the jets, possibly detectable by Cassini's visible and infrared cameras and spectrometers, might be a key to revealing the sizes of ice grains in the jet.

More information: S. Kempf, U. Beckmann, J. Schmidt, How the Enceladus dust plume feeds Saturn's E ring, *Icarus* 206, 446-457 (2010)

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