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Gaps, Waves, and Propellers in Saturn's Rings

The embedded moon Daphnis creates three waves in Saturn's rings in this image taken by the spacecraft Cassini during its grand final . Credit: NASA/JPL-Caltech/Space Science Institute

After more than a decade observing Saturn, Cassini completed its mission in style: A grand finale sent the spacecraft on almost 2 dozen dives between the planet and the rings before it took its final descent into Saturn's atmosphere.

During these trips in 2017, Cassini collected high spatial resolution images and spectral and temperature scans of the rings. In a paper published in June in *Science,* researchers dove into these high-resolution data, and their synthesis revealed new features inside the rings that hadn't been seen before (bit.ly/saturns-rings). They found sculpted areas within the rings—including banded textures and disturbances from embedded bodies—that can be used to help theorists narrow in on how Saturn and its rings may have formed.

Ring Disruptions

During the grand finale, Cassini took the highest-fidelity images ever taken of the rings. "We found a number of things that are new—a number of structures that we'd never been close enough to see before," said Matthew Tiscareno, a senior research scientist at the SETI Institute in Mountain View, Calif., and lead author of the paper.

The team explored disturbances related to moons or smaller moonlike debris embedded in the rings. The moon Daphnis, for example, leaves a wide trail of disruption in its wake, including a wide gap in the ring and trailing waves of debris.

These waves, Tiscareno explained, are created by the rings moving at different speeds: The rings orbiting closer to Saturn move at speeds faster than those farther from the planet. This process creates a shear flow, and "on the outward edge, the ring part, the ring material is falling behind Daphnis and its orbit," he said.

> "We found a number of things that are new—a number of structures that we'd never been close enough to see before."

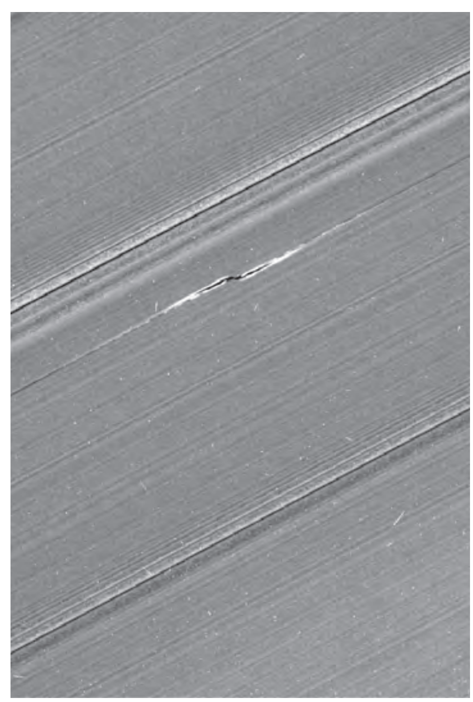
But it's not just big moons like Daphnis that cause disruptions. Smaller objects are trying their best to create ring gaps as well, but with less success. "These are objects that are 10 times smaller, which means they're a thousand times less massive," said Tiscareno. Instead of forming a gap, he said, these objects form a propeller-shaped disturbance.

The researchers knew the propellers existed, so they directed Cassini to perform some targeted flybys to get a closer look. "The details of that [propeller] structure [are] telling us exactly how big the moons are at the center of the propeller...about a kilometer across," said Tiscareno, adding that at that size, it's not possible to see the actual moon with these image resolutions.

Ring Textures

Cassini's instruments also revealed new details on textures within the rings. "We knew that there were textures before, but we had not seen them as comprehensively," said Tiscareno. The team noted that the ring textures ranged from strawlike clumps to feathery regions, with sharp edges on their borders.

One idea for the different textures within the rings is a changing particle composition, said Douglas Hamilton, an astronomer at the



This propeller, informally called Bleriot, formed within Saturn's rings. Propellers are caused by a central moonlet that alters the ring as it orbits around the planet. Credit: NASA/JPL-Caltech/Space Science Institute

University of Maryland who was not involved with the paper. For example, one part of the ring could be more silicate rich, whereas another area has more ice. But Hamilton said that the researchers "make a good case" for these textures being caused by something other than composition.

The team inferred that the sharp borders along the ring textures were not due to a composition change, said Tiscareno, but instead result from the physical properties of the ring particles.

One physical property might be the roughness of ring particles. Tiscareno explained: Is a ring particle more like a billiard ball or more like a snowball? Roughness can affect not only the reflection of light but also how particles interact with each other. "Do they bounce off of each other, like billiard balls do?" he asks. "Or are they kind of sticky, like a snowball would be?"

"Rings are our only natural laboratory to understand disk processes more generally—and that goes to understanding baby solar systems."

Forming a Ring

Getting close-up data from Cassini gives researchers information that reaches beyond our nearby ringed planet. "Rings are our only natural laboratory to understand disk processes more generally. And that goes to understanding baby solar systems, which are disk systems where you have massive objects that are embedded in the disk," said Tiscareno. "We're seeing massive objects embedded in the rings, and we're seeing the disk itself doing things that we didn't expect."

Hamilton said that papers like this help uncover how features like propellers might form. "The theory is our imagination," Hamilton said. Work like this paper, he added, allows theoretical researchers to test their models on Saturn's rings against observed data.

"[These data are going] to be the basis for 10 years of effort by the entire field in trying to figure out how to make all this [propellers, textures] happen," said Hamilton.

By **Sarah Derouin** (@Sarah_Derouin), Freelance Journalist

Poaching Elephants Reduces Carbon Storage in Forests

Forest elephants splash and play at a forest's edge in the Dzanga-Sangha Special Reserve in the Republic of the Congo. Credit: iStock.com/ANDREYGUDKOV

A tropical rain forest drapes over central Africa in the Congo Basin, covering an area 3 times the size of Texas. The forest is the second-largest tropical forest in the world, behind only the Amazon in South America.

African forests have taller trees and fewer tree species than other tropical forests, and researchers have long postulated that Africa's forest elephants are responsible. Forest elephants are "ecosystem engineers" that change the type of plants that survive in the forest.

But a study in *Nature Geoscience* in July found that African elephants do more than garden the Congo: They help the forests store more carbon in their trees (bit.ly/carbon-stocks-enhanced). The latest findings indicate that 7% of carbon stores in central African rain forests will be lost if elephant populations continue to plummet because of poaching for ivory and shrinking habitats.

Trees suck up carbon dioxide when they photosynthesize, and they repurpose the carbon into their trunks, branches, and roots. Certain trees have higher carbon densities, especially trees that are hardwood and slow growing. Elephants encourage the growth of slow growing trees by clomping through the forest and eating, squishing, and knocking over fast growing softwood trees, which they find more palatable.

Researchers in the latest study created a computer model to assess the influence of elephants on vegetation in an undisturbed forest. The model mimicked elephants' impact by giving smaller trees in the model a lower survival rate. After 250 years of elephant intervention, the forest trees were taller and wider and held more carbon above ground than before. The results agreed with field data from forest study sites.

According to the model, elephants boost the forest's carbon-carrying capacity by 3 billion tons of carbon. France emits a similar amount of carbon through fossil fuel emissions over the course of 27 years, lead author Fabio Berzaghi told *Eos*.

As countries release more carbon dioxide into the atmosphere, governments are looking for cost-effective ways to sequester carbon. Yet as poaching reduces elephant populations, which have fallen by 90% over the past century, the study's findings indicate that the amount of carbon stored in the African forest will drop as well. Berzaghi said that there's no way to know how much has already been lost.

Berzaghi noted that countries are missing out on a natural way to store carbon. "Carbon technologies, at the moment, are really expensive," Berzaghi said. "Nature offers a lot of these services for free."

By **Jenessa Duncombe** (@jrdscience), News Writing and Production Fellow