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Using eclipses to calculate the transparency of Saturn's rings

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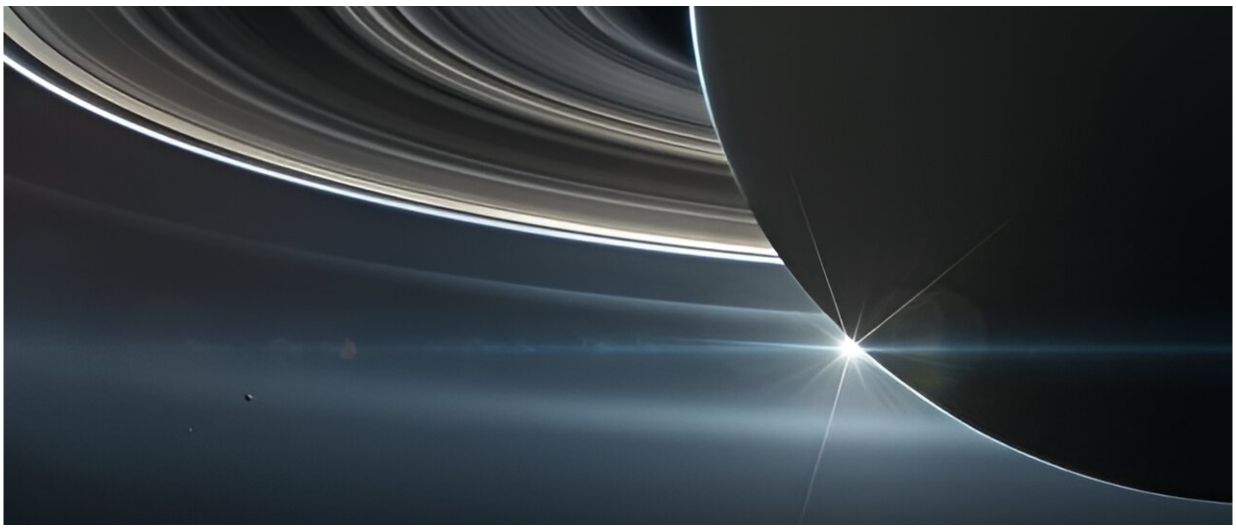

An illustration of the Cassini spacecraft orbiting Saturn. Credit: NASA/JPL-Caltech

A Lancaster University Ph.D. student has measured the optical depth of Saturn's rings using a new method based on how much sunlight reached the Cassini spacecraft while it was in the shadow of the rings.

The optical depth is connected to the transparency of an object, and it shows how far light can travel through that object before it gets absorbed or scattered.

The research, led by Lancaster University in collaboration with the Swedish Institute of Space Physics, is published in the *Monthly Notices of the Royal Astronomical Society*.

The NASA-ESA Cassini spacecraft was launched in 1997 and reached Saturn in 2004, carrying out the most extensive survey of the planet and its moons to date. The mission ended in 2017 when Cassini plunged into the Saturnian atmosphere, after diving 22 times between the planet and its rings.

Lancaster University Ph.D. student George Xystouris, under the supervision of Dr. Chris Arridge, analyzed historic data from the Langmuir Probe on board Cassini, an instrument that was measuring the cold plasma, i.e., low energy ions and electrons, in the magnetosphere of Saturn.

For their study they focused on solar eclipses of the spacecraft: periods where Cassini was in the shadow of Saturn or the main rings. During each eclipse, the Langmuir Probe recorded dramatic changes in the data.

George said, "As the probe is metallic, whenever it is sunlit, the sunlight can give enough energy to the probe to release electrons. This is the photoelectric effect, and the electrons that are released are so-called 'photoelectrons. They can create problems though, as they have the same properties as the electrons in the cold plasma around Saturn and there is not an easy way to separate the two."

"Focusing on the data variations we realized that they were connected with how much sunlight each ring would allow to pass. Eventually, using the properties of the material that the Langmuir Probe was made of, and how bright the sun was in Saturn's neighborhood, we managed to calculate the change in the photoelectrons number for each ring, and calculate Saturn's rings optical depth.

"This was a novel and exciting result! We used an instrument that is mainly used for plasma measurements to measure a planetary feature, which is a unique use of the Langmuir Probe, and our results agreed with studies that used high-resolution imagers to measure the transparency of the rings."

The main rings, which extend up to 140,000 km from the planet, but have a maximum thickness of only 1km, are to disappear from view from Earth by 2025. In that year the rings will be tilted edge-on to Earth, making it almost impossible to view them. They will tilt back towards Earth during the next phase of Saturn's 29-year orbit and will continue to become more visible and brighter until 2032.

Professor Mike Edmunds, the President of the Royal Astronomical Society, added, "It is always good to see a postgraduate student involved in using space probe instrumentation in an unusual and inventive way. Innovation of this kind is just what is needed in astronomical research—and an approach which many former students who are in a variety of careers are applying to help address the world's problems."

More information: Georgios Xystouris et al, Estimating the optical depth of Saturn's main rings using the Cassini Langmuir Probe, *Monthly Notices of the Royal Astronomical Society* (2023). DOI: 10.1093/mnras/stad2793

Provided by Lancaster University