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Observations of ejecta clouds produced by impacts onto Saturn's rings

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Quantifying the mass flux onto Saturn's rings has long been a desired goal for several reasons. Mass infall likely dominates the rings' coloration and their levels of non-ice pollution, as well as influencing angular momentum transport and erosion of particles, all of which in turn have the potential to set limits on the age of the rings. Additionally, direct measurement of the mass infall onto Saturn's rings would constrain the population of interplanetary dust in the outer solar system, which is poorly determined at present. However, previous efforts to detect impacts onto Saturn's rings have been unsuccessful.

The first unambiguous images of dust clouds above Saturn's rings, which we interpret as impact clouds, were acquired by the Cassini orbiter during the 2009 saturnian equinox. The main rings provided an unusually dark background, due to sunlight shining edge-on to the dense disk, while dust extending vertically out of the ring plane was fully illuminated. The dust clouds showed evidence of significant keplerian shear, indicating that they were produced within a short period of time and that subsequently each constituent particle evolved on an independent keplerian orbit. One sheared dust cloud was imaged in the C ring (∼81,600 km from Saturn center) and a larger one in the A ring (∼129,400 km from Saturn center), the latter extending ∼200 km radially and more than 5,000 km azimuthally. The time elapsed since impact (or "age") is indicated by the angle of the sheared structure; the A ring impact was observed on two occasions separated by about a day, and indeed the age of the sheared impact cloud was about 24 hours at the first apparition, and 48 hours at the second.

Several impacts onto Saturn's rings were also likely imaged by Cassini in 2005 in the C ring (∼84,000 km from Saturn center), enabled by the highest phase angles of any high-resolution image ever obtained of the rings. These structures are smaller and more frequent (they appear in most images with the required phase and resolution) than the 2009 equinox detections, and are smeared by motion of the object during image exposure.

We identify these observed dust clouds as ejecta produced by impacts onto the rings, as this is by far the most likely mechanism for producing such a cloud with the required rapidity. The implications for projectile size, velocity, and frequency will be discussed.