Circumplanetary Dust: Spokes in Saturn's B Ring

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An enduring mystery that has eluded planetary scientists for almost forty years is the origin of the ghostly spokes that appear in Saturn's main rings. Spokes are dark and roughly radial features that are seen on the lit side of Saturn's rings, although they sometimes also appear as bright features on the dark side. This scattering behavior is indicative of dusty material and detailed analysis yields a typical particle size of slightly less than a micron. The radiation and electromagnetic perturbations that act on dust are small on these visible spokes particles, so they must follow nearly Keplerian orbits. Spokes are seen to begin as purely radial features which gradually become triangular in shape as particles at different distances from Saturn orbit at different angular rates. For the first few hours, however, one side of a triangular spoke typically remains vertical, indicating active generation of new dusty material along that edge.

For the past several years, we have progressed in developing a physical model involving a collisional cascade of dust particles to explain these observations. The process starts with an interplanetary impact into the ring that creates myriad dust grains of different sizes in a single localized spot. For simplicity, consider just two sizes: visible micron-sized spoke particles and invisible submicron sized dust. Tiny invisible submicron grains are strongly affected by Saturn's magnetic field which causes them to gyrate around field lines just as ions do. After these particles are ejected from a parent ring, they leave the ring plane, are accelerated to high relative speed by the magnetic field, and then return to a different radial location. When they strike ring particles at high speed, they create further submicron grains that can continue the process. In this way, an initially localized disturbance is propagated radially in the rings. With each submicron impact, some visible micron-sized material is also created to become visible as spokes. We identify the length of time that an edge is active with the time in which the collisional cascade is ongoing.

To test our Collisional Cascade model, we are currently analyzing 10,000 images of Saturn's rings taken by Cassini (see example below, unfolded into ring radius vs. longitude). We are developing a pipeline to identify and catalog spokes in each of the images with the goal of generating a large database that can be used to answer statistical questions. We will be able to look for changes in spoke behavior with spoke age, with the season on Saturn, and with longitude and radius in the ring. These investigations will provide important new constraints on spoke behavior and will put to the test our Collisional Cascade model as well as other models that hope to explain spokes. In this paper, we will give an update on the status of the project.