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The Structure of Saturn's E ring as seen by Cassini CDA

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Abstract

The Cassini onboard dust detector, CDA, measures the mass, speed, charge, and composition of individual ring particles. Thus, the size and speed distribution of the E ring particles can be derived from CDA measurements obtained during Cassini's ring traversals. Because there is a close connection between the ring particle dynamics and the distribution of ring particle speeds, CDA provides precious information about the processes sculpting the ring. Here we present speed and size distributions measured inside and outside the orbit of the dominating ring particle source, the active ring moon Enceladus. We also present radial density profiles of the inner E ring obtained during equatorial ring traversals, which show a pronounced dependence of the ring structure on the hour angle.

1. Introduction

Saturn's diffuse E ring is the largest ring of the solar system and extends from about 3.1 R_S (Saturn radius R_S = 60 330 km) to at least 20 R_S, encompassing the icy moons Mimas, Enceladus (3.95R_S), Tethys (4.88R_S), Dione (6.25R_S), and Rhea (8.73R_S). The ring is composed of predominantly water ice grains [4] smaller than $10\mu m$ [9, 7]. Numerical studies of the ring particle dynamics suggest particle lifetimes of less than 200 years [6, 5, 8], implying that a mechanism resupplying the ring with fresh dust must exist. The ice moon Enceladus was proposed to be the dominant dust source from early on, because the ring's radial density profile shows a pronounced maximum at the moon's orbital distance [1]. During a close Cassini flyby at Enceladus, Cassini instruments discovered a gas-dust-plume emerging from Enceladus' south pole region [11, 13, 3, 2]; a site characterised by elongated cracks [10] significantly warmer than their surroundings [12]. Measurements by the Cassini dust detector showed that Enceladus is by far the most dominant, and perhaps the only, source of fresh ring particles.

2. Size- and speed distribution of E ring particles

There is an intimate connection between the dynamics of the ring particles and their spatial distribution. The most effective way to obtain information about the ring particle dynamics, however, is to measure the particles' speed distribution at various points within the ring. If all ring particles have the same semi-major axis (which is approximately the case for young ring material detected close to the orbit of Enceladus), then the speed distribution is directly related to the distribution of the ring particles' eccentricities. Our measurements, however, indicate that except in the vicinity of Enceladus' orbit the ring particle population is characterised by a broad distribution of their semi-major axis and the eccentricities. We present here, for the first time, direct measurements of the statistical properties of the ring particle ensemble which will help us to understand better the complex dynamics of the E ring.

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