EPSC Abstracts
Vol. 7 EPSC2012-701 2012
European Planetary Science Congress 2012

The 3-dimensional structure of Saturn's E ring inferred from Cassini CDA observations

S. Kempf (1), M. Horanyi (1), A. Juhasz (1, 2), A. Cruz (1), R. Srama (3), F. Postberg (3), F. Spahn (4) and J. Schmidt (4)
((1) LASP, Colorado University at Boulder, USA (sascha.kempf@lasp.colorado.edu), (2) Wigner Research Center for Physics, Budapest, Hungary, (3) IRS, Universität Stuttgart, Germany (4) Universität Potsdam, Germany

Abstract

Seven years of Cassini observations dramatically changed our understanding of Saturn's diffuse dust ring . Before Cassini's insertion into its orbit around Saturn in 2004, the E ring was thought to extend from $3\,\mathrm{R_S}$ to $7\,\mathrm{R_S}$ (Saturn radius $\mathrm{R_S} = 60\,330\mathrm{km}$) and to be dominantly composed of micron-sized water ice grains. In-situ observations by Cassini's Cosmic Dust Analsyer (CDA) showed, however, that the ring extens at least until Titan's Orbit ($\approx 20\,\mathrm{R_S}$) and that the ring particle population ranges between a few nanometers and few tens of micrometers [15]. Recent observations by the Cassini camera ISS and by CDA revealed a complex ring morphology [3, 7]. The radial density profile of the ring turned out to depend on the longitude relative to Sun. On the morning side the ring's density peak is inside the orbit of the ring's source moon Enceladus, while on the evening side the density peak is exterior of Enceladus's orbit.

1. Introduction

Saturn's diffuse E ring is the second-largest known planetary ring of the solar system extending from $3.1\,\mathrm{R_S}$ to approximately Titan's orbit [15] and enclosing the ice moons Mimas, Enceladus, Tethys, Dione, and Rhea [5]. Due to the ring's radial brightness peak at the orbital distance of Enceladus, the moon was identified early as the dominant ring particle source [1]. Recent observations by the Cassini spacecraft, which is in orbit around Saturn since July 2004, revealed that the ring particles mostly originate from localised sources of dust and water vapour in the geologically active south–pole terrain of Enceladus [12, 13, 2]. The ring is composed of $0.3 \leq s_d \leq 4\,\mu\mathrm{m}$ radius grains consisting of water ice and tiny solid impurities [4, 6, 8, 9, 10]. The radial distribution of the ring particles is well described by a pair of power laws centred at the densest point within the ring [11], which is displaced outwards from the Enceladus orbit by at least $0.05\,\mathrm{R_S}$ [6].

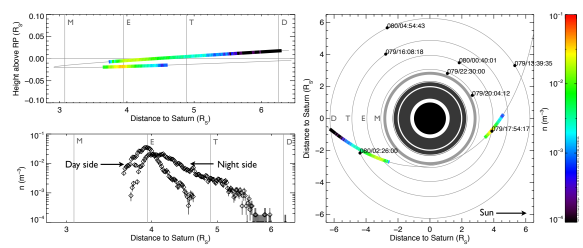

Figure 1: Radial density profile for grains $\geq 0.9\,\mu\mathrm{m}$ obtained during Cassini's almost equatorial traversal of the inner E ring in orbit 128 (lower left plot). On the night side the ring flares out while on the day side the ring is strongly "compressed" towards Saturn. Because the traversal took less than a day, the radial profiles are due to the same dust population.

Recent observations by the Cassini dust detector CDA [7] as well the Cassini camera ISS [3] indicate that the dynamics of E ring particles must be more complex than perceived by the authors of the aforementioned works. The radial density profile of the ring turned out to depend on the longitude relative to Sun. On the morning side the ring's density peak is inside the orbit of the ring's source moon Enceladus, while on the evening side the density peak is exterior of Enceladus's orbit (see Fig. 1). Hedman et al. also reported that the ring's vertical thickness as well as the ring color vary with longitude relative to the Sun, but does not vary with longitude to the source moon Enceladus. In turn, the CDA shows that the location of the densest point in the ring shows a pronounced dependence on the grain size [7].

2. CDA measurements of the E ring properties

They key for correctly modeling the dynamical processes responsible for shaping the ring is the (local) distribution of ring particles' orbital elements. This information cannot be obtained from remote sensing observations, because the ring brightness is the result of the superposition of a large number of ring particles sometimes moving in very different orbits. In-situ dust detectors like CDA measure the impact speed which is directly related to the orbital elements of the striking particles. In fact, the Cosmic Dust Detector (CDA) on Cassini [14] is capable of directly measuring all relevant properties of individual ring particles: i) speed, ii) mass, iii) composition, and iv) the electrostatic charge carried by the grains.

Here we present the 3 dimensional morphology of the E ring reconstructed from vertical and equatorial dust density profiles obtained by CDA between 2004 and 2012.

References

[1] W. A. Baum et al. *Icarus*, 47:84–96, 1981.

[2] C. J. Hansen et al. *Nature*, 456:477–479, 2008.

[3] M. M. Hedman et al. *Icarus*, 217:322–338, 2012.

[4] J. K. Hillier et al. The composition of Saturn's E ring. *Mon. Not. Roy. Astron. Soc.*, 377:1588–1596, 2007.

[5] M. Horányi, J. A. Burns, M. M. Hedman, G. H. Jones, and S. Kempf. Diffuse Rings. In Dougherty, M. K., Esposito, L. W., & Krimigis, S. M., editor, *Saturn from Cassini-Huygens*, pages 511–536. Springer, 2009.

[6] S. Kempf et al. *Icarus*, 193:420–437, 2008.

[7] S. Kempf et al. In *EPSC-DPS Joint Meeting 2011*, page 1643, October 2011.

[8] F. Postberg et al. *Icarus*, 193:438–454, 2008.

[9] F. Postberg et al. *Nature*, 459:1098–1101, 2009.

[10] F. Postberg et al. *Nature*, 474:620–622, 2011.

[11] M. R. Showalter, J. N. Cuzzi, and S. M. Larson. *Icarus*, 94:451–473, 1991.

[12] F. Spahn et al. *Science*, 311:1416–1418, 2006.

[13] J. N. Spitale and C. C. Porco. *Nature*, 449:695–697, 2007.

[14] R. Srama et al. *Space Science Reviews*, 114:465–518, 2004.

[15] R. Srama et al. *Planet. Space Sci.*, 54:967–987, 2006.