EPSC Abstracts
Vol. 11, EPSC2017-590-1, 2017
European Planetary Science Congress 2017

Dust characteristics of dusty plasma ring of Saturn

M. W. Morooka (1), J.-E. Wahlund (1), S.-Y. Ye (2), A. M. Persoon (2), and W. S. Kurth (2)
(1) Swedish Institute of Space Physics (IRFU), Uppsala, Sweden, (2) Department of Physics and Astronomy, University of Iowa, Iowa City, IA, USA (morooka@irfu.se)

Abstract

During the Ring Grazing orbit, starting from December 2016, Cassini carried out twenty of the faint Saturn ring crossing observations at the distance of 2.45-2.51 R_S ($1R_S \sim 60{,}268$ km) from Saturn center. We will show the electron and the ion density measurements of the RPWS/Langmuir Probe (LP) during these orbits. In most of the orbits significant ion/electron density differences have been observed, which indicates the presence of the charged nm and μm sized grains. The relationship between the observed charge densities and the electrical potential of the grains shows that the grains and the ambient electrons and ions are electro dynamical ensemble, a dusty plasma. The results show that characteristic dust size changes depending on the distance from the ring center. The result suggests that a dusty plasma state is related to the dynamics of the grain sizes.

1. Introduction

Near the Enceladus and its surrounded E ring Cassini observations revealed that the nm and μm sized charged dust grains are abundant and playing an important role in the plasma dynamics; the dusty plasma [1], [2]. In such region, a large unbalance of the ion and the electron densities (the ion density higher than the electron density) had been observed. Dusty plasma can be expected in other place of the ring system, especially in the faint rings that is composed of nm and μm size small grains such as the F ring [3].

2. Results

Series of the ring passage observation show a consistent dust and plasma structure around the equator:

1) Relatively dense plasma disk has been observed in both the electron and the ions around the equator at $|Z_{KME}|<1R_S$.

2) An additional sharp ion density increasing has been observed at $|Z_{KME}|<0.1R_S$. The observed densities at the equator were several 10^2 cm^{-3} for ions, while the electron density remains a few 10 cm^{-3}. The density ratio of the electrons to the ions (Ne/Ni) were close to or less than 0.1 at the equator.

3) The μm sized dust density enhancement has been observed in the region. However, the region was narrower ($|Z_{KME}|<0.02R_S$) than the ion density enhancement region. This suggests that the characteristic size of the negative charged particles varies depending on the distance from the ring center. On the other hand, the dominant part of the negative charges is carried by the nm size small grains in all the region where the electron/ion density difference have been observed.

5) The density ratio of the electrons to the ions has variations over the five months of Dust Grazing orbits. It had decreasing variation in the first eight Dust Grazing orbits (the orbit 251, doy339 2016 to the orbit 258, doy023 2017), and then sharply increased at orbit 267 and in a decreasing phase again.

In addition, the plasma wake effect has been observed in a few orbits when the LP is located in the downstream of the ideal co-rotation of the spacecraft, which means that the observed LP current are not due to the secondary effect of the dust but the plasma ions flowing around the spacecraft.

The observed plasma and dust parameters are important not only in suggesting the presence of the dusty plasma near the F ring, but also showing an importance of the small nm size grains as a negative charge carrier in a dusty plasma [4], [5]. Numbers of close optical investigations of F rings by Cassini showed the highly variable F ring structure that is affected by the orbits of the nearby object [6] and the dust size characteristics are also variable in different region. The relationship of the dust size distribution and the dust state obtained here implies a complex

dusty plasma dynamics related to the dynamics of the grain aggregation and the shattering processes.

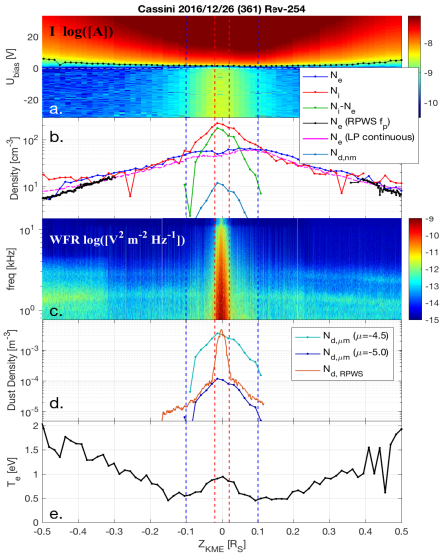

Figure 1: The summary of the Langmuir probe observation during one of the ring crossing. Panels show from the top: VI spectrogram of the LP, the densities of the charged particles, µm sized dust observation of RPWS, the estimated µm sized grain density, and the electron temperature.

References

[1] Wahlund, J.-E. et al. (2009), Detection of dusty plasma near the E-ring of Saturn, Planet Space Sci, 57(1), 1795–1806, doi:10.1016/j.pss.2009.03.011.

[2] Morooka, M. W., J.-E. Wahlund, A. I. Eriksson, W. M. Farrell, D. A. Gurnett, W. S. Kurth, A. M. Persoon, M. Shafiq, M. André, and M. K. G. Holmberg (2011), Dusty plasma in the vicinity of Enceladus, Journal of Geophysical Research, 116(A12), A12221–, doi:10.1029/2011JA017038.

[3] Goertz, C. K. (1984), Formation of Saturn's spokes, Advances in Space Research, 4(9), 137–141, doi:10.1016/0273-1177(84)90018-8.

[4] Meyer-Vernet, N., 2013. On the charge of nanograins in cold environments and Enceladus dust. *Icarus*, 1306, pp.583–590. Available at: http://www.elsevier.com/locate/icarus.

[5] Yaroshenko, V.V., Lühr, H. & Miloch, W.J., 2014. Dust charging in the Enceladus torus. *Journal Of Geophysical Research-Space Physics*, 119(1), pp.221–236. Available at: http://doi.wiley.com/10.1002/2013JA019213.

[6] Cuzzi, J. et al., 2009. Ring Particle Composition and Size Distribution. , p.459. Available at: http://adsabs.harvard.edu/cgi-bin/nph-data_query?bibcode=2009sfch.book..459C&link_type=ABSTRACT.