EPSC Abstracts
Vol. 8, EPSC2013-519, 2013
European Planetary Science Congress 2013

Day/night side asymmetry of ion densities and velocities in Saturn's inner magnetosphere

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Abstract

Measurements from the Cassini Radio and Plasma Wave Science (RPWS) Langmuir probe (LP) shows a day/night side asymmetry in the ion density and velocity of the inner plasma disk of Saturn. The variation is largest in the region 4 to 5.5 R_S from the planet. The ion density in this region varies from around 35 cm^{-3} at noon to around 80 cm^{-3} at midnight. The ion velocity variation in this region ranges from around 28-32 km/s at noon to 36-40 km/s at midnight. The variation could be explained by a noon to midnight electric field which would introduce an extra E×B drift component that would cause the density and velocity variations detected by the Cassini LP.

1. Introduction

The Cassini satellite has been orbiting Saturn since 2004 and have provided us with many important discoveries about the Saturnian system. Among the most important ones are the discovery that the moon Enceladus expels water vapor and condensed water from ridges and troughs located in the moon's south polar region [2]. This constant feeding of new material creates a neutral disk around Saturn along the orbit of Enceladus. From the neutral disk charge exchange, photoionization, and impact ionization are creating a plasma disk. Lately several studies (e.g. [1], [5]) have presented local time variations in a number of parameters related to the inner plasma disk of Saturn. We show that this variation is also visible in the Cassini LP ion density and velocity measurements.

2. Observations

2.1. RPWS LP experiment methods

A full description of the RPWS instruments can be found in [3]. The LP measurements are performed by sweeping the probe between -32 and 32 V and measuring the current generated by the attracted and repelled plasma particles. From the measured current the ion density n_i and the azimuthal ion velocity $v_{i,\theta}$ are derived. A full description of the used method is presented in [4].

2.2. Results

We use the derived ion densities and velocities to investigate the local time dependence found in the inner plasma disk of Saturn. The local time system has 12 o'clock towards the Sun and is in the anti-clockwise direction seen from above the north pole of Saturn. The LP data is recorded between the 1st of February 2005 and the 27th of June 2010, and limited to 0.5 R_S in z-direction. Figure 1 shows the ion density for various local times and radial distances from Saturn. The region is divided into 0.8 hours and 0.4 R_S bins and an average of the data located in each bin is presented. The variation is largest in the region 4 to 5.5 R_S, where it ranges from ∼35 cm^{-3} to ∼80 cm^{-3}.

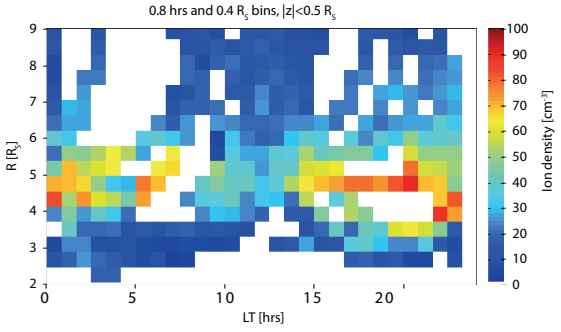

Figure 1: The ion density as a function of radial distance R and local time LT. In the region between 4 and 5.5 R_S there is a clear density minimum on the day side and a maximum on the night side.

The day/night side asymmetry can also be seen in the ion velocity. Figure 2 shows that the ion velocity variation in the region 4 to 5.5 R_S ranges from around 28-32 km/s at noon to 36-40 km/s at midnight.

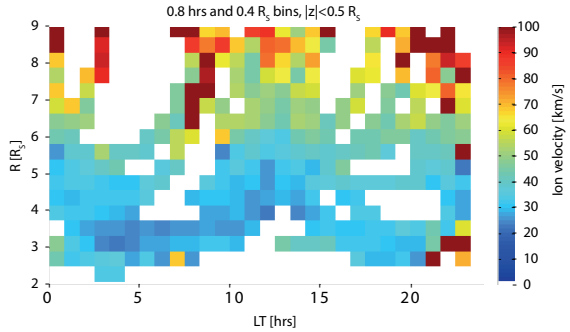

Figure 2: The ion velocity as function of radial distance R and local time LT. In the region between 4 and 5.5 R_S there is a velocity minimum on the day side and a maximum on the night side.

3. Discussion and Conclusions

The day/night side asymmetry seen in the LP data could be explained by a previously suggested noon to midnight electric field. This field could also be the cause of the local time asymmetries seen in other parameter related to the inner plasma disk, detected by other Cassini instruments [5]. A noon to midnight electric field would give the ions an extra E×B drift component pointing towards Saturn as the particles move from dusk to midnight and outwards from Saturn as they move from dawn to noon. This would cause the density to be lower at the dayside and higher at the nightside for the same radial distance from Saturn. An electric field of 0.1-1 mV/m [1] would give a velocity difference of 1-12 km/s between noon and midnight. The velocity difference seen in the LP data is around 5-10 km/s. We conclude that the Cassini LP can contribute with further evidence of the previously suggested noon to midnight electric field around Saturn. The origin of this convection electric field is still unknown.

Acknowledgements

The Swedish National Space Board (SNSB) supports the RPWS/LP instruments on board Cassini.

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