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Investigation of Titan's ion environment during plasmasheet type encounters

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Abstract

It was established during recent years of Cassini's surveys of Titan's environment that the plasma populations in its vicinity are highly variable (e.g. by Rymer et al., 2009). We use this categorization to further investigate the plasmasheet type encounters. Using the Time of Flight measurements of the Ion Mass Spectrometer sensor of the Cassini Plasma Spectrometer we determined the large scale plasma composition at Titan for particle species of m/q=1, 2, 16-19, 28-40. With a simple test particle simulation we study the distribution of heavy ion species of Titan origin during different upstream scenarios - for individual flybys - modeling encounters when Titan was embedded in (or very close to) Saturn's plasma sheet.

1. Introduction

Titan is embedded in the co-rotating magnetospheric plasma of Saturn. Magnetic field and particle measurements show periodic fluctuations in the surrounding plasma, which are associated with the Kronian plasma sheet (e.g. [1]). The fluctuations are organized by the SKR periodicity [2]. [4] categorized 54 Titan encounters using combined CAPS and MIMI electron data to describe its background plasma environment. Four different electron populations have been identified: plasmasheet, lobe-like, magnetosheath and bi-modal. [3] have conducted a similar analysis for CAPS ions.

2. Data analysis

The Ion Mass Spectrometer (IMS) sensor of the Cassini Plasma Spectrometer (CAPS) measures all ion species between 1eV-30keV (Figure 1). The gray shading marks the interval when Cassini enters the ionosphere, the red lines mark the obstacle boundaries (mass loading boundary and mantle).

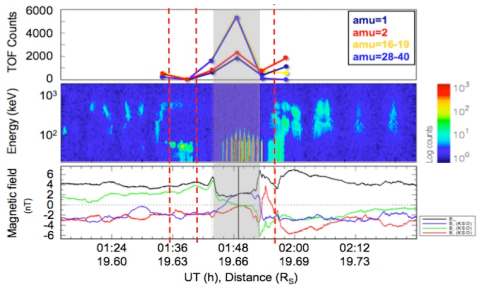

Figure 1: Distribution of major ion components derived from CAPS-TOF measurements (top panel), CAPS-IMS dynamic spectrum (middle panel) and magnetic field data in KSO coordinates.

3. Composition analysis

With our method it is possible to distinguish between four major ion groups and species using the TOF measurements of CAPS-IMS. This was applied to two flyby groups of T25-T32 (Figure 3) and T35-T51.

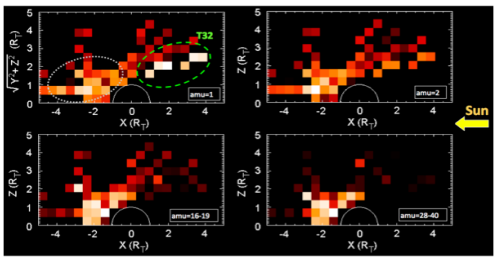

Figure 3: Normalized TOF counts of different ion species measured by CAPS for T25-T32.

The data is plotted along the spacecraft trajectory in TSE coordinates (the Sun is in the positive x direction) within 5 RT in the x-z plane. Since Titan

was close to the nose of the magnetopause the theoretical corotation direction is approximately perpendicular to the plane of the figure.

4. Plasmasheet type encounters

A list of studied plasmasheet type flybys is shown in Table 1. When Titan is close to the plasmasheet (or magnetodisc from a magnetic field approach) it is subjected to higher flux plasma in a tilted magnetic field configuration.

Flyby Nr.	Date (Year-DOY)	SLT (hrs)
T29	2007-116	13.67
T34	2007-200	18.8
T36	2007-275	11.47
T39	2007-354	11.33
T49	2008-356	10.4
T51	2009-086	10.0
T52	2009-094	22.0
T53	2009-110	22.0
T55	2009-141	22.0

Table 1: List of plasma sheet type flybys analysed in this study.

5. Test particle method

A test particle code is being developed to apply for a tilted upstream magnetic field configuration that is observed during a plasmasheet type encounter. The particle trajectories are calculated in a curved magnetic field using an ideal induced magnetosphere-approximation for the regions in Titan's vicinity. The density pWe solve the equations of motion for the four main ion groups distinguished in this study. The goal is to observe the possible process scenarios of the main plasma constituents at the detection point in order to estimate their origin and propagation characteristics.

6. Summary and Conclusions

This paper introduces the approach of our ongoing work to interpret the plasma measurements detected by CAPS-IMS for four distinct groups of plasma components. We calculated the relative densities of these ion species in order to determine their distribution in Titan's vicinity and their propagation characteristics during plasmasheet type encounters. We are currently developing a method to track the ions in a curved magnetic field configuration using real parameters from Cassini measurements for the upstream conditions at Titan. We compare the results of the simulation with the CAPS-IMS measurements.

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