Titan's tail structure: multi-instrument study by Cassini

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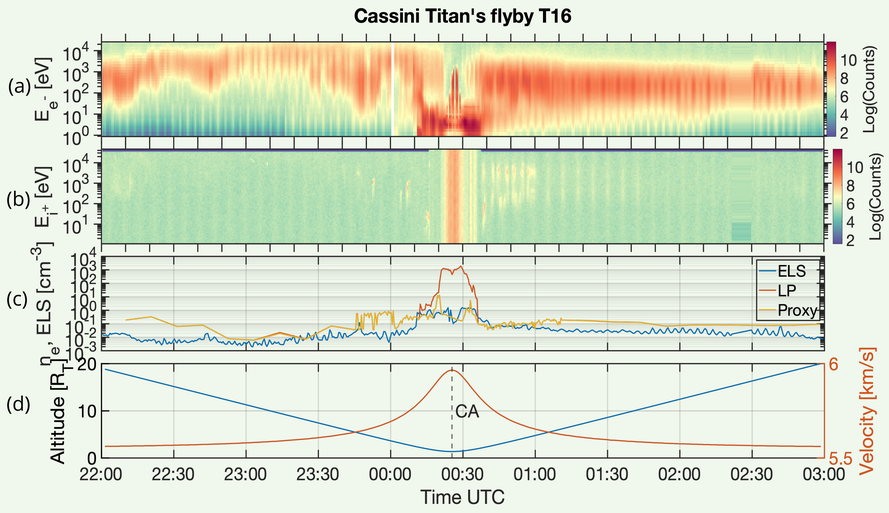
1 Introduction

Titan's plasma tail is formed as a result of the interaction of Saturn's magnetospheric flow with Titan's ionosphere. While the ionosphere is created mainly by EUV radiation and impinging magnetospheric particles on the atmosphere, the tail is more governed by plasma outflow processes, the upstream magnetospheric flow properties (density, flow velocity) and the upstream magnetic field direction. The properties of Titan's tail have previously been studied with both numerical simulations and in-situ measurements

In this work, we make an attempt to combine observations of electrons and ions in Titan's tail for all of the Cassini flybys. We use the Langmuir probe (RPWS/LP) and the Cassini Plasma Spectrometer (CAPS) for ion and electron measurements. We put a spatial constraint on the tail's geometry and its orientation based on the measurements of electron and ion densities. The estimation of the escape rate is revisited, and different sources of variability and their impact on the tail structure are discussed. Furthermore, the link between the conventional electric field **E** = -**v**×**B** and the electron density distribution is studied. The interim result is that the electron density tends to have higher densities in the hemisphere of the positive upstream electric field. This is observed in the altitudes below the dynamo region, which is the chemistry-dominated region. The explanation of the observed distribution tendency is discussed. We show that draped magnetospheric field lines are draped around Titan, forming an extended magnetotail lobes-like region.

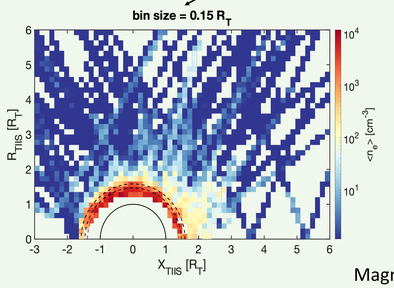
2 Methods

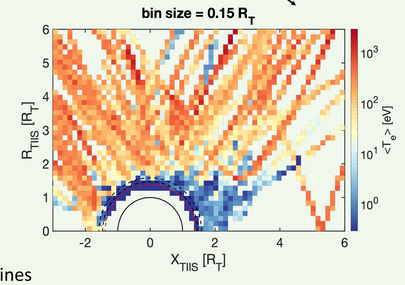


The Cassini's instruments RPWS/LP and CAPS/ELS measure the densities and temperatures of electrons. In dense and cold plasmas RPWS/LP provides reliable measurements of the electron plasma properties. However, in tenuous and hot plasmas CAPS/ELS works more efficiently. To have a continuous electron density and temperature profile throughout the flyby, we have combined measurements from these instruments. In the figure above an example of such a routine has been demonstrated. From top to the bottom: (a,b) energy-time spectrogram of electrons and ions, (c) continuous profile of the electron density, (d) superposed S/C altitude and velocity.

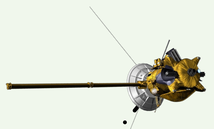
3 Combined measurements of RPWS/LP and CAPS/ELS: initial results

The electron density map reveals an extended tail region with cold dense electrons (~100 cm^{-3}, ~1-10 eV).



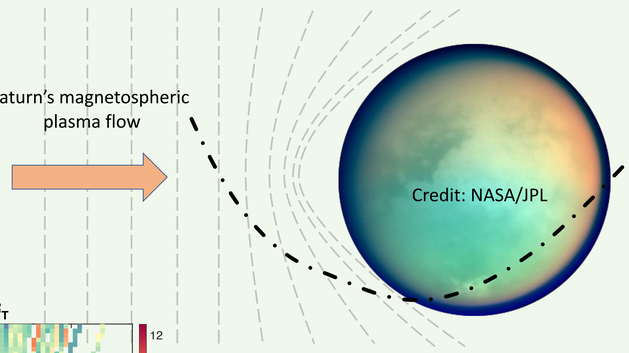


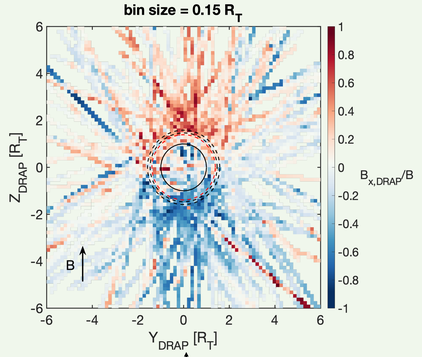
Magnetic field lines



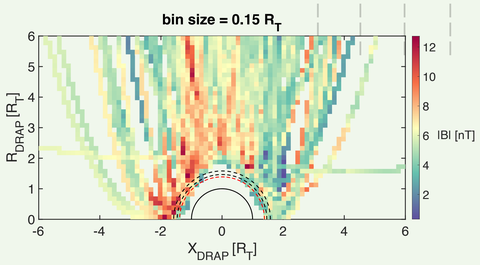
Cassini's flyby geometry

Saturn's magnetospheric plasma flow



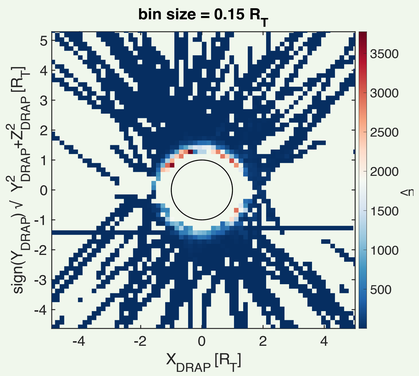


The magnetotail lobes are formed as a result of Saturn's magnetic field draping around Titan.



The magnetic pile-up region is observed on the ramside with an average increase of the magnetic field magnitude up to 12 nT.

4 Future plans



Now when the constraints on Titan's tail geometry are found, the outflowing plasma composition is of interest. To obtain ion composition we use CAPS/IMS time-of-flight data. The flow direction is estimated using the field-of-view from CAPS/IMS data as well.

Another feature was found which is related to a slightly asymmetrical electron density distribution with more electrons found in the direction of the upstream electric field. The cause of this asymmetry Is yet to be found.

We are also interested in various sources of variations, e.g., solar irradiance, Saturn's magnetosphere perturbations, Saturn's rotational modulation and etc, and how this sources impact on tail's structure and outflow rates.

5 Interim conclusions

1. An electron density map reveals an extended outflow region in the tail direction with an electron density of ~100 cm^{-3} and temperature of ~1-10 eV.
2. The draping of Saturn's magnetic field on Titan's ramside gives rise to the magnetic field strength of an average of 12 nT.
3. Two magnetotail lobes are created as a result of the magnetic field draping
4. An asymmetry of the electron density with respect to the upstream magnetic field is found. The result has to be confirmed. There is no clear explanation of such a phenomenon found (yet).