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# Titan's Topside Ionospheric Composition: Cassini Plasma Spectrometer Ion Mass Spectrometer Measurements

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## Abstract

We present ion composition measurements of Titan's topside ionosphere using T15 Cassini Plasma Spectrometer (CAPS) Ion Mass Spectrometer (IMS) measurements. The IMS is able to make measurements of Titan's ionosphere due to ionospheric outflows as originally reported by [1] for the T9 flyby. This allows one to take advantage of the unique capabilities of the CAPS IMS which measures both the mass-per-charge (M/Q) of the ions and the fragments of the ions produced inside the sensor such as carbon, nitrogen and oxygen fragments. Specific attention will be given to such ions as NH4+, N+, O+, CH4+, CxHy+, and HCNH+ ions as examples.

## 1. Introduction

[1] were the first to quantitatively show ion outflows (r > 10,000 km) ~ 5x1024 ions/s coming from Titan's ionosphere using the CAPS IMS data for the T9 flyby. Later it was shown by [2] that ionospheric outflows for T63 and T75 were also occurring at similar levels ~ 5x1024 ion/s. [3] showed evidence for ionospheric outflows for the T15 wake flyby. [1] were the first to use the T9 outflows to make compositional estimates of Titan's topside ionosphere (i.e., composition freezes in for altitudes greater than exobase altitude ~ 1400 km) and concluded that CH5+ and C2H5+ were the dominant ions of these outflows.

Normally, the CAPS IMS cannot be used to measure Titan's relatively dense ionosphere because the IMS has high sensitivity to measure the more tenuous plasmas of Saturn's magnetosphere and its detectors will experience count rates beyond their maximum allowed rates, therefore the IMS was configured not to measure the ionospheric ions. But, whenever there are high altitude Titan wake flybys such as T9, T15, T63, and T75, the ion densities are low enough that CAPS IMS count rates are within operational limits, so the IMS can be configured to measure these ionospheric outflows and measure the composition of these outflows.

## 2. Compositional Analysis

The CAPS IMS which uses a time-of-flight (TOF) technique which measures both straight through (ST) and linear electric field (LEF) TOF data. The ST data measures the neutral and negative fragments exiting the instrument's carbon foil while for the LEF data positive ions exit the carbon foil. The ST data allows the IMS to measure the M/Q of the atomic and molecular ions, while the LEF gives information about the atomic fragments. In order to perform this analysis we have had to use composition data of both the flight model and the prototype model of the IMS for which the latter resides at GSFC. This analysis requires one to know the relative probabilities of the ST and LEF data, as well as the probabilities between the ion peaks within the ST and LEF spectra, respectively. In order to get the relative probability between C+ and O+ fragments we've used $CO^+$ and $CO_2^+$ data at a range of energies from 64 V to 30 kV, respectively. We also used the $CO_2^+$ data to give us the line profiles for $C^+$ for the $C_3H_m^+$ and $C_4H_m^+$ ions since we only have calibration data for $C_nH_m^+$ for n = 1 and 2. We've also had to use published data probabilities for $C^+$, $N^+$ and $O^+$ data [4], [5] and [6]. In the future we would like to get calibration data for $C_nH_m^+$ for n = 3 and 4, $HCN^+$ for relative probability between $C^+$ and $N^+$ and $NO^+$ data for relative probability between the $N^+$ and $O^+$ fragments.

## 3. Summary and Conclusions

By using IMS compositional measurements of T15 ionospheric outflows, and using the various pieces of compositional data and published probabilities of ions penetrating carbon foils at different energies, we will show evidence for methane group ions, nitrogen ions, ammonium ions, water group ions and CnHm+ ions with n = 2, 3, and 4 within Titan's topside ionosphere.

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