Electron temperature(s) in Titan's ionosphere: re-analysis of the Cassini RPWS/LP data

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Abstract

The Cassini Langmuir Probe (LP) data, part of the Radio and Plasma Wave Science (RPWS) investigation, in Titan's ionosphere are re-analyzed with the main goal to finely measure the electron temperature on all the dataset. The LP sweeps in this region are particularly difficult to fit and interpret.

We have found that several maxwellian electron components were needed to correctly fit the data. It seems that at least two electron populations of different temperatures are present. Statistical studies show that the main component gives an electron temperature slowly varying with Solar Zenith Angle. However, a second electron population often appears at lower altitudes and has a temperature more dependent on solar irradiation.

1. Introduction

The ionosphere of Titan is particularly complex to understand. The main gases of Titan's atmosphere are nitrogen and methane and, once ionized, they trigger a very complex chemistry. This leads to the formation of complex ions and even organic solid aerosols above 1200 km [1].

Ionospheric models [2] compute an electron temperature lower than what has been previously found with the Cassini Langmuir Probe (LP) data [3]. We guess that the complex chemistry happening in Titan's ionosphere could be part of the explanation.

Therefore, we re-analyzed LP data in Titan's ionosphere, focusing on the electron temperature. We investigated all the 64 flybys of the Cassini mission where the spacecraft went below 1300 km.

2. Electron temperature(s) measurements

2.1 RPWS/LP method description

This study is based on the RPWS/LP sweep mode measurements during which the LP samples the total current of the charged particles to the probe between ±4 V.

The current-voltage curves characteristics give estimates of several plasma parameters, including the electron temperature (Te). The electron part of the sweep is fitted supposing a maxwellian distribution for electron speed and using the sheath limited theory.

2.2 Several populations?

For most of the LP sweeps below 1300 km, the data could not be exactly fitted with only one general electron component (as done in [3]) for calculating electron temperature. In these cases, we had to use 2 to 4 components. It could be due to different electron populations in the probe surroundings.

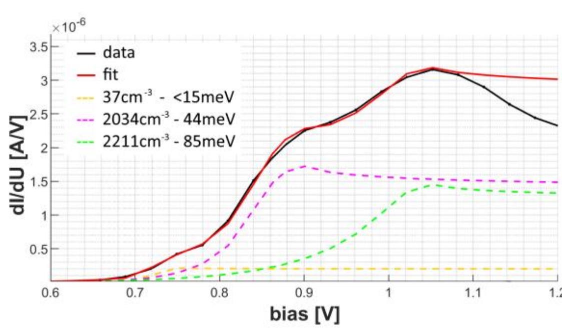

Figure 1: LP sweep at 966km on T104. Current derivative and fit.

3. Results

3.1 Evolution with altitude

The altitude profiles of the electron density and the temperature for the different populations show that each population evolves differently. In many cases a 'hotter' population (green curve) appears at lower altitudes.

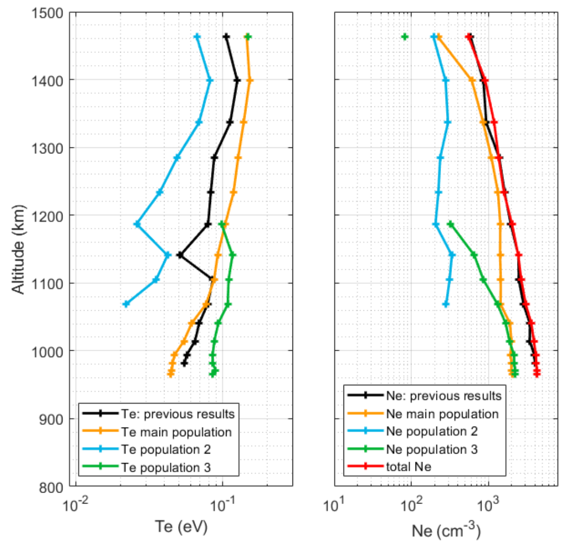

Figure 2: Altitude profile of electron density and temperature on the inbound of T104. Three electron populations. Comparison with results obtained with one population.

3.2 Statistics

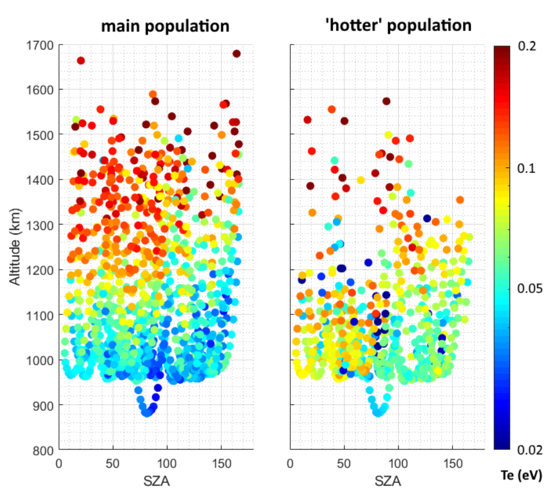

Figure 3: Electron temperature as function of altitude and solar zenith angle. Statistics on 38 flybys.

The analysis of all the Cassini dataset enables a statistical study of electron densities and temperatures.

For the main population, temperatures decrease from 0.2 to 0.04 eV for altitudes from 1500 km to 900 km. Only a small variation of ~0.01 eV is seen with Solar Zenith Angle (SZA).

The 'hotter' population is more variable with SZA. This population seems therefore more sensitive to solar radiations.

4. Summary and Conclusions

The re-analysis of Cassini LP dataset in Titan's ionosphere showed that the data are better fitted using several maxwellian components. Therefore, it seems that the complexity of Titan's ionosphere leads to LP measurements harder to interpret. Are there several electron populations from different origins? In the ionospheric conditions, electrons should be thermalized and should show only one population. Further studies using statistics are ongoing to find out if the complex chemistry happening at these altitudes does play a role in these observations.

Acknowledgements

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