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Detection of negative ions in the deep ionosphere of Titan during the Cassini T70 flyby

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Abstract

We present radio and plasma wave science (RPWS) Langmuir probe (LP) observations that give evidence for a population of heavy, negative ions at altitudes below 900 km in Titan's ionosphere during the Cassini T70 flyby. The negative ion density in this region is comparable to, or higher than, the electron density of 760 cm^{-3}. Both positive and negative ions are moving with a velocity of at least a few hundred m s^{-1} relative to Titan. We show two limiting cases where we have analysed RPWS/LP ion measurements. The data can be interpreted as either that a population of negative ions with density comparable to the electron density is present, moving at a very high (>2 km s^{-1}) velocity, or that the ion population is moving at a few hundred m s^{-1}, but with a density an order of magnitude larger than the electron density in the same region.

1. Introduction

The electron spectrometer (ELS) part of the Cassini plasma spectrometer (CAPS) onboard the Cassini spacecraft has been used to detect heavy, negative ions in the deep (<1400 km) ionosphere of Titan [1,2]. Here, we use LP data to report on findings from the T70 Titan flyby. This is the only detection of negative ions at such low altitudes at Titan, since the spacecraft attitude for this flyby was unfavourable for the CAPS/ELS instrument, which could have performed complementary measurements.

1.1 The T70 flyby

The T70 flyby is to date the flyby of Titan reaching the lowest altitude. The closest approach (CA) occurred at 880 km, about 70 km deeper than any previous flyby. The SZA at CA was 81 degrees and the latitude was 82 degrees north. This means that T70 occurred both in the latitude region and very close to the region of SZAs where maximum negative ion masses have previously been detected by ELS. According to Coates et al. [2009], ion masses of up to 9000 amu/q are expected for this flyby based on ELS measurements at higher altitudes.

2. Results

A detailed investigation of the LP sweep data shows that negative ions must be present in order to explain the measurements. Figures 1 and 2 show two possible fits to the ion current measured by the LP at 01:27:51 UT. The different solutions are restricted by the zero crossing and the inclination of the derivative.

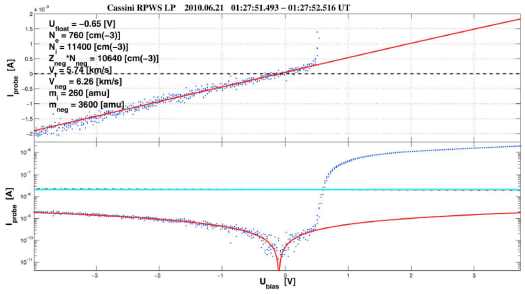

Figure1. The current-voltage characteristics of a sweep at 01.27.51 UT of flyby T70. The x-axis shows applied bias voltage to the probe. The data: (top) linear and (bottom) logarithmic. The LP data are shown as blue dots. Superposed are the total current (red line), the negative ion current (blue line), the ion current (red dot-dashed line) and the photoelectron current (black dashed line). For this sweep the ion velocity, v_i, was set to 260 ms^{-1}[3].

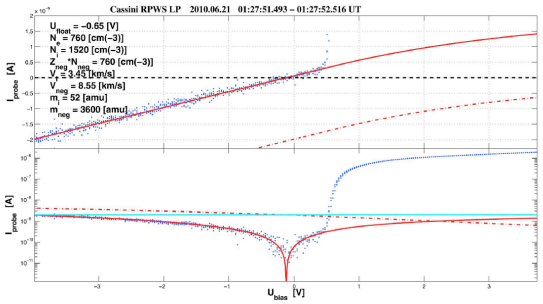

Figure 2. Same as for Figure 1, except for the negative ion density being set to the electron density, $n_{i\_} = n_e$. [3].

6. Summary and Conclusions

We conclude that there are substantial amounts of negative ions present in the deep ionosphere of Titan, with a density in the range of around 1000 up to more than 10 000 cm^{-3}/Z and a velocity of at least a few hundred m s^{-1}, possibly as high as a few km s^{-1}. W have for the first time used the LP alone to detect a significant amount of negative ions in the deep ionosphere of Titan and confirm the findings of Coates et al. [1,2]. This result is important as it constrains the ionospheric plasma composition around Titan. Furthermore, negative ions are believed to be important in the formation of tholins and these findings provide further clues to this process.

Acknowledgements

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References

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