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Titan's ionosphere: a survey of solar EUV influences

O. Shebanits (1,2), E. Vigren (1), J.-E. Wahlund (1), M.K.G. Holmberg (3,4), M. Morooka (1), N.J.T. Edberg (1), K.E. Mandt (5,6), J.H. Waite Jr (6)

(1) Swedish Institute of Space Physics, Uppsala, Sweden.

(2) Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden.

(3) Université de Toulouse, UPS-OMP, IRAP, Toulouse, France

(4) CNRS, IRAP, Toulouse, France

(5) Department of Physics and Astronomy, University of Texas at San Antonio, San Antonio, Texas, USA.

(6) Space Science and Engineering Division, Southwest Research Institute, San Antonio, Texas, USA.

Corresponding author: Oleg Shebanits (oleg.shebanits@irfu.se)

Abstract

We present a study of the effects of solar EUV on positive ions and heavy negative charge carriers in Titan's ionosphere, including 78 flybys below 1400 km altitude between TA (Oct 2004) and T120 (June 2016). Statistically significant variations with respect to the solar EUV flux are seen in the RPWS/LP-measured ion charge densities (normalized by the solar zenith angle). From solar minimum to maximum: dayside – a factor ~2 increase, nightside – a factor ~3-4 *decrease*. The overall EUV trends suggest that the idealized Chapman theory does not apply below at least 1200 km in Titan's ionosphere. Nightside charge densities also vary along Titan's orbit, being higher in the sunward magnetosphere of Saturn compared to the magnetotail.

1. Introduction

Titan is the largest moon of Saturn, hosting a fully developed atmosphere extending to almost a whole radius above its surface [1]–[3], [4 and references therein]. Dayside atmosphere is ionized mainly by the solar EUV with ionization peak at ~1100 km altitude [5]–[8]. Nightside at altitudes below 1200 km is mainly ionized by the energetic particle flux from the Kronian magnetosphere [9]–[11]. *In-situ* observations of deep ionosphere (880 – 1000 km altitudes) have revealed negatively charged ions/dust particles (~5 nm) [12] with charge densities ≳ free electrons [7], [13], [14]. With accumulation of data by the Cassini s/c spanning over one solar cycle, the influence of the latter on Titan's ionosphere is under scientific scrutiny: solar maximum enhancement of the electron [15] and the lighter (<100 amu) positive ion number densities [16] have been shown. In this study we extend the picture with the ion population, adding the heavier positive ions and the negative ions/dust grains from the *in situ* measurements by the Radio and Plasma Wave Science (RPWS) Langmuir probe (LP) on board the Cassini s/c.

2. Results and conclusions

The solar EUV flux has a strong impact on the ion and dust grain charge densities: a factor ~2 correlation on the dayside and a factor ~3-4 anti-correlation on the nightside (from min. to max. flux, see Figure 1). During the maximum solar activity the altitudes of the peak charge densities decrease for the positive ions and increases for the negative ions/dust grains, reflecting changes of chemical production. We conclude that a higher solar EUV flux changes the photochemistry of the upper atmosphere (leading to the observation of less ions on the nightside than at a lower EUV flux) and may then have implications for the aerosol production below the altitudes reachable by the Cassini s/c.

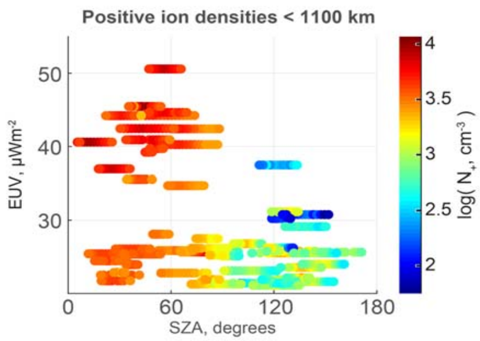

Figure 1. The positive ion number density (color-coded, log scale), plotted in EUV flux (<80 nm, integrated) vs solar zenith angle (SZA), showing the difference in the EUV dependencies on the dayside (SZA<70) and the nightside (SZA>110).

The nightside ion charge densities at ~1000 km altitude is shown to vary along the Titan's orbit, being higher in the sunward magnetosphere than in the magnetotail, consistent with enhanced particle flux intensity from the magnetotail towards sunward magnetosphere, detected by the ENA instrument [17]. The altitude of these variations is in agreement with the peak ionization by the magnetospheric particle precipitation [4], [11].

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