EPSC Abstracts
Vol. 7 EPSC2012-307 2012
European Planetary Science Congress 2012
ⓒ Author(s) 2012

The effective recombination coefficient in Titan's sunlit upper atmosphere

E. Vigren (1), M. Galand (1), R. V. Yelle (2), J. Cui (3,4), J.-E. Wahlund (5), K. Ågren (5), P. P. Lavvas (6), I. C. F. Mueller-Wodarg (1) and D. F. Strobel (7).

(1) Department of Physics, Imperial College, London, U. K. (2) Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA, (3) School of Astronomy and Space Sciences, Nanjing University, Nanjing 210008, China. (4) National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China. (5) Swedish Institute of Space Physics, Uppsala, Sweden. (6) Groupe de Spectrométrie Moléculaire et Atmosphérique, Université Reims Champagne-Ardenne, Reims, France. (7) Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD, USA. (e.vigren@imperial.ac.uk / Fax: +44-20 7594 7772)

Abstract

On the dayside, Titan's main ionospheric region (with observed electron densities often exceeding 3000 cm^{-3}) is located at altitudes between 1000 and 1200 km. The production of free electrons occurs mainly through photoionization of N_2 and CH_4 and the loss of the electrons happens primarily through dissociative recombination with positively charged molecular ions yielding neutral products. Knowledge of the effective recombination coefficient, $k(z)$, at different altitudes, z, in Titan's ionosphere is important in order to get a better understanding of the ionospheric structure. Neglecting electron transport and assuming 1) that number densities of negative ions are minute and 2) that steady state conditions applies, $n_e(z)$, is related to $k(z)$ and the electron production rate, $P_e(z)$, according to

$$P_e(z) = k(z) \times (n_e(z))^2 \qquad (1)$$

We use an energy deposition model combined with Cassini data from four Titan encounters to assess the effective recombination coefficient in Titan's sunlit upper atmosphere via Eq. (1). We use N_2 and CH_4 density profiles derived by the Ion Neutral Mass Spectrometer (INMS) in order to determine $P_e(z)$. The XUV/EUV solar spectrum impinging on the top of the atmosphere is obtained from measurements with the TIMED/SEE instrument. We use thermal electron number densities and electron temperatures, T_e, derived from measurements with the Langmuir Probe, a subsystem of the Cassini Radio and Plasma Wave Science (RPWS) experiment. The T_e data is needed to transfer the obtained $k(z)$ values to their corresponding values, k_{300}(z), at a reference electron temperature of 300 K assuming a standard electron temperature dependence of the effective recombination coefficient. We find a good agreement between the altitudes where the calculated electron production rates are peaking and the altitudes where the observed electron number densities are peaking. We find that the effective recombination coefficient at a reference electron temperature of 300 K, k_{300}, increases with decreasing altitudes, which we attribute to the increased complexity of the ion population towards lower altitudes and laboratory results from dissociative recombination reactions of individual ion species. At low altitudes the derived values of k_{300} are less than the ones derived by Galand et al. (2010, J. Geophys. Res. 115, A07312), primarily as a result of the revised INMS neutral densities. We obtain, $k_{300}(z)$ values, which appear to be too high (by about a factor of 2-3) judging from laboratory measurements and comparisons with the (number density weighted) average rate coefficient among the major ion species in Titan's upper atmosphere (e.g., $HCNH^+$, $C_2H_5^+$, CH_3CNH^+, $HCCCNH^+$). We will discuss potential reasons for the discrepancy found.

Acknowledgements

E.V. thanks the Swedish Research Council (contract No. 2011-894) for financial support. We acknowledge support from the EU through the FP7/DEPTH grant.