EGU21-2726
https://doi.org/10.5194/egusphere-egu21-2726
EGU General Assembly 2021

Heavy positive ion groups in Titan's ionosphere: Cassini Plasma Spectrometer IBS observations

Richard Haythornthwaite[1,2], Andrew Coates[1,2], Geraint Jones[1,2], Anne Wellbrock[1,2], Hunter Waite[3], Véronique Vuitton[4], and Panayotis Lavvas[5]

[1]University College London, Mullard Space Science Laboratory, Space & Climate Physics, Dorking, UK
[2]The Centre for Planetary Sciences at UCL/Birkbeck, London, UK
[3]Space Science and Engineering Division, Southwest Research Institute, San Antonio, Texas, 78228, USA
[4]Institut de Planétologie et d'Astrophysique de Grenoble, Univ. Grenoble Alpes, CNRS, Grenoble 38000, France
[5]Université de Reims Champagne Ardenne, CNRS, GSMA UMR 7331, 51097 Reims, France

Introduction

Titan is the largest moon of Saturn and has a thick extended atmosphere along with a large ionosphere. Titan's ionosphere contains a plethora of hydrocarbons and nitrile cations and anions as measured by the Ion Neutral Mass Spectrometer and Cassini Plasma Spectrometer (CAPS) onboard the Cassini spacecraft[1].

Previous ion composition studies in Titan's ionosphere by Cassini instruments revealed "families" of ions around particular mass values and a regular spacing of 12 to 14 u/q between mass groups [2]. These are thought to be related to a carbon or nitrogen backbone that dominates the ion chemistry[2]. Previous studies also identified possible heavy ions such as naphthalene, anthracene derivatives and an anthracene dimer at 130, 170 and 335 u/q respectively[1].

Methodology

The CAPS Ion Beam Spectrometer[3] is an electrostatic analyser that measures energy/charge ratios of ions. During the Titan flybys Cassini had a high velocity (~6 km/s) relative to the low ion velocities (< 230 m/s) observed in the ionosphere. The ions were also cold, having ion temperatures around 150K. The combination of these factors meant that the ions appeared as a highly-directed supersonic beam in the spacecraft frame. This means the ions appear at kinetic energies associated with the spacecraft velocity and the ion mass, therefore the measured energy spectra (eV/q) can be converted to mass spectra (u/q).

Results and Conclusions

Positive ion masses between 170 and 310 u/q are examined with ion mass groups identified between 170 and 275 u/q containing between 14 and 21 heavy (carbon/nitrogen/oxygen) atoms[4]. These groups are the heaviest positive ion groups reported so far from the available in situ ion data at Titan.

The ion group peaks are found to be consistent with masses associated with Polycyclic Aromatic Compounds, including Polycyclic Aromatic Hydrocarbon (PAH) and nitrogen-bearing polycyclic aromatic molecular ions. The ion group peak identifications are compared with previously proposed neutral PAHs[5] and are found to be at similar masses, supporting a PAH interpretation. The spacing between the ion group peaks is also investigated, finding a spacing of 12 or 13 u/q indicating the addition of C or CH. Lastly, the occurrence of several ion groups is seen to vary across the five flybys studied, possibly relating to the varying solar radiation conditions observed across the flybys.

The discovery of these groups will aid future atmospheric chemical models of Titan through identification of prominent heavy positive ions and further the understanding between the low mass ions and the high mass negative ions, as well as the process of aerosol formation in Titan's atmosphere.

References

1. Waite et al., The Process of Tholin Formation in Titan’s Upper Atmosphere, Sci., 2007, doi:10.1126/science.1139727

2. Crary et al., Heavy ions, temperatures and winds in Titan's ionosphere: Combined Cassini CAPS and INMS observations, P&SS, 2009, doi:10.1016/j.pss.2009.09.006.

3. Young et al., Cassini Plasma Spectrometer Investigation. Space Sci. Rev., 2004, doi:10.1007/s11214-004-1406-4

4. Haythornthwaite et al., Heavy Positive Ion Groups in Titan's Ionosphere from Cassini Plasma Spectrometer IBS Observations, eprint arXiv:2009.08749

5. López-Puertas et al., Large Abundances of Polycyclic Aromatic Hydrocarbons in Titan's Upper Atmosphere, ApJ, 2013, doi:10.1088/0004-637X/770/2/132