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Simultaneous Cassini VIMS and UVIS observations of Saturn's southern aurora

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Abstract

Here, temporally simultaneous and spatially overlapping Cassini VIMS and UVIS observations of Saturn's southern aurora are presented. The pointing is fixed at a constant local time of 04:55, covering latitudes between 64°S and 82°S and longitudes between 127° and 186°. The spatial resolution is high, with 1 mrad covering ∼300 km, such that only a small part of the pre-dawn aurora is observed. Ultraviolet auroral H and H_2 emissions from UVIS are compared to infrared H_3^+ emission from VIMS.

The auroral emission is structured into three arcs – H, H_2 and H_3^+ are morphologically identical in the bright main auroral oval (∼73°S), but there is an equatorward arc that is seen predominantly in H (∼70°S), and a poleward arc (∼74°S) that is seen mainly in H_2 and H_3^+.

These observations indicate that, for the main auroral oval, the UV emission is a good proxy for the infrared H_3^+ morphology (and vice versa), but for emission either poleward or equatorward this is no longer true. Hence, given the highly dynamic nature of the aurora of Saturn, simultaneous UV/IR observations are crucial for completing the picture of how the atmosphere interacts with the magnetosphere.

1. Introduction

The bulk of the neutral atmosphere of Saturn is comprised of H, H_2 and He, together with simple hydrocarbons. These species are ionised by both solar ultraviolet radiation (UV) and energetic charged particles impacting the atmosphere, producing H_3^+ via H_2^+, and to a lesser extent H^+. Given that H, H_2 and H_3^+ are have different mixing ratios at different altitudes, their emission can reveal the energy of the precipitating particles, their magnetospheric origin and the conditions of the upper atmosphere.

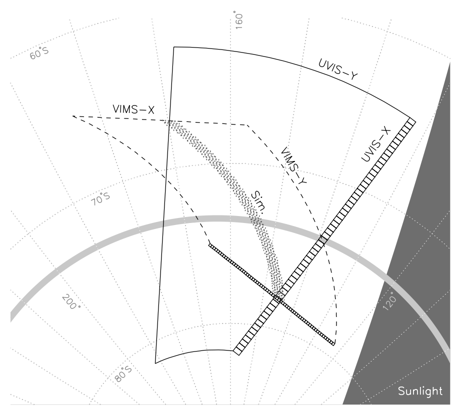

Figure 1: Schematic showing the UVIS (soild) and VIMS (dashed) latitude-longitude projected field of view, with the swath of simultaneity (dotted area, labelled 'Sim.'). The grid has as spacing of 10° in both latitude and longitude, with the south pole towards the bottom. Individual pixel projections are shown at the starting point of each instrument FOV. The light grey line shows the average location of the southern auroral oval [1]. The dark grey area to the right shows the sunlight at the start of the observation.

The only simultaneous UV/IR observations of giant planet aurora published to date is that of [2], who observed Jupiter with the NASA IRTF and HST. Despite having very different spatial resolutions, the observations reveal both similarities and intriguing differences between the IR and UV, especially pole-ward of the main auroral oval. For Saturn however, no such study has been undertaken.

With Cassini currently in orbit at Saturn it is possible to observe Saturn's aurora with the Visual Infrared Mapping Spectrometer (VIMS) and the Ultraviolet Imaging Spectrograph (UVIS) simultaneously.

2. Cassini Observations

This set of observations consists of 17 UVIS exposures and 1 complete VIMS data cube taken on the 10th of September 2008, for about an hour. The spatial resolution is high - a VIMS pixels covers 150 km^2. Each UVIS exposure has 64 spatial pixels, whereas each VIMS cube have 64 $\times$ 64 spatial pixels that are integrated each in sequence, each being exposed for 1 second.

The observational geometry is depicted in Figure 1. Note that these observations are projected to longitude and latitude. If they were to be projected to local-time, all the UVIS observations would stack atop each other.

Due to the geometry and operational modes of the instruments only a small part of these observations are both temporally and spatially simultaneous – this swath is labelled 'Sim' in Figure 1.

3. Results & Discussion

From the UVIS observations H Lyman α and H_2 Lyman and Werner band emissions are extracted and mapped – seen in Figure 2. From the VIMS observations, H_3^+ R band emissions at 3.5 μm is extracted.

The H panel in Figure 2 shows two arcs, one bright discrete (the main arc) that moves pole-ward throughout these observations. There is also a equatorward diffuse arc. Both of these arc are seen in the H_2 panel, with the addition of a third arc poleward of the main one. This third arc is also seen in the H_3^+ panel, with the distinct absence of the equatorward arc seen in the UV.

The morphological differences between the species highlight the very dynamic nature

We derive a temperature for the main arc of 440 $\pm$ 50 K, with a H_3^+ column density of 7 $\times$ 10^{15} m^{-2}. The primary electron energy for the main arc is on the order of a few keVs for the main arc and 100s of eVs for both the equatorward and poleward arcs [4]. Based

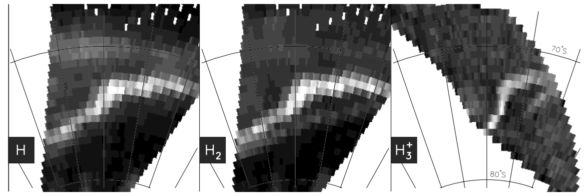

Figure 2: The UVIS and VIMS observations of Saturn's southern aurora for H, H_2 and H_3^+. The geometry is identical to that of Figure 1.

on the UV intensities the equatorward, main and poleward arc require 0.33, 0.8 and 0.25 mWm^{-2} of precipitation energy respectively [3].

The morphological differences between the hydrogen species observed here are likely due to different particle energies impacting the atmosphere, creating excitation and ionisation at different altitudes. These observations also highlight the very dynamic nature of the kronian aurora.

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