Simultaneous infrared and ultraviolet observations of Saturn's aurora using Cassini VIMS and UVIS

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Electron impact on a molecular hydrogen atmosphere

- $e^-$
- $e^-$
- $e^-$

H and H$_2$ excitation - UVIS

H$_2$ ionization

H$_3^+$ production

H$_3^+$ quasi-thermalized emission - VIMS
Why look at simultaneous infrared and ultraviolet observations of the aurora?

- $\text{H}_3^+$ spectrum = ionospheric temperature and density
- $\text{H}_3^+$ radiative cooling rates
- $\text{H}_2$ spectrum = electron energy
- $\text{H}_2$ FUV intensity = precipitation flux
- Morphology = magnetospheric origin
- $\text{H}, \text{H}_2, \text{H}_3^+$ sensitive to different precipitation energies = precipitation energy spectrum
VIMS/UVIS Geometry

- VIMS (infrared) and UVIS (ultraviolet) point in the same direction and their field-of-views (FOVs) overlap.
- A typical UVIS auroral exposure is 240 seconds.
- A typical VIMS exposure is <1s per pixel <1h per 64 x 64 FOV.
- UVIS integrates 1024 spectral elements each for 64 spatial pixels同时.
- VIMS integrates 256 IR spectral elements for one pixel at a time – total of 64 x 64 integrations per cube.
Operating VIMS and UVIS in standard modes simultaneously - 2008 DOY 254

Cassini pointing fixed in local-time at southern pole. These plots are projected to lat/lon.

Spatial resolution VIMS ~150 km
Case study: 2008 DOY 254

H, H$_2$, and H$_3^+$

There are three distinct arcs 1) diffuse equator-ward, 2) main oval, moving northward 3) weak poleward bifurcation
Parameterizing atmospheric response to auroral input:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Equatorward</th>
<th>Main</th>
<th>Poleward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>70°S</td>
<td>73°S</td>
<td>74°S</td>
</tr>
<tr>
<td>Arc FWHM (° latitude)</td>
<td>2.0</td>
<td>1.5</td>
<td>1.2</td>
</tr>
<tr>
<td>FUV intensity (kR)</td>
<td>2.1</td>
<td>5.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Precipitation energy (mWm$^{-2}$)</td>
<td>0.33</td>
<td>0.80</td>
<td>0.25</td>
</tr>
<tr>
<td>$H_3^+$ temperature (K)</td>
<td>–</td>
<td>440 ± 50</td>
<td>–</td>
</tr>
<tr>
<td>$H_3^+$ density ($10^{15}$ m$^{-2}$)</td>
<td>–</td>
<td>7 ± 1</td>
<td>–</td>
</tr>
<tr>
<td>$H_3^+$ cooling (mWm$^{-2}$)</td>
<td>–</td>
<td>0.3</td>
<td>–</td>
</tr>
</tbody>
</table>

- Intensity along the simultaneous VIMS/UVIS FOV
- Each arc highlighted
- ~40% of precipitation energy flux is radiated to space by $H_3^+$ although Joule heating likely to be dominant.
- The main oval (arc) is not hotter than the auroral region average of 450±50 of Melin et al. (2007).
Simultaneous VIMS/UVIS observations - future work

- 331 simultaneous VIMS/UVIS auroral observations prior to 2010
- Instruments operated in standard modes.
- Variety of geometries - equatorial orbits and inclined orbits (esp. 2008).
- Quantitative study to follow
2008-201 Polar emissions

H$_3^+$ dominated:
Hot and/or soft PP
H, H2, and H3+ bright: Hard PP at pole
2008-206 Limb obs.

Figure 10: 2008-206T14:22:24.6490, $d = 20.6R_S$, UVIS exp time 240.0 s
Summary

- Simultaneous UV/IR observations of Saturn’s aurora can yield a more complete picture of the energetics of the magnetosphere/ionosphere/thermosphere interaction.

- The morphologies of auroral H, H\textsubscript{2}, and H\textsubscript{3}\textsuperscript{+} are not necessarily the same!

- 40% of precipitation energy by is radiated away by H\textsubscript{3}\textsuperscript{+} (and H\textsubscript{2} to a lesser extent)

- Lots of work to do!