Simultaneous Cassini, HST, and ground-based observations of Saturn’s aurorae during the 2013 auroral campaign

Henrik Melin


UVIS Team Meeting 17/06/14

Space Environment Technologies
University of Leicester
Motivation

• Observe the same phenomenon in multiple wavelengths (i.e. what is the relationship between ultraviolet H, H₂ and infrared H₃⁺ emissions?)

• Observe aurora from multiple vantage points simultaneously (dayside/nightside).

• Observe auroral emission at many spatial scales (i.e. on what spatial and temporal scales do we observe variability?).

• Icarus special issue!
• Lots of auroral observations in March and April 2013


• Cassini observing nightside, Earth-based platforms observing the day-side.
• Consider an interval of 8 hours during which 6 instruments observed, covering \( \sim 3/4 \) of Saturn rotation.

• At most 5 instruments were observing at the same time.

• Shift observing times to be time of emission at Saturn (i.e. shift Earth-based observations back by 4,403 seconds.)
HST - ACS

- 2.4 m telescope in low-Earth orbit, launched in 1990
- ACS was installed 2002, by Shuttle service mission 3B.
- Wide field images of UV wavelengths, including H2 Lyman & Werner bands
- Science products:
  - Brightness
Hubble Space Telescope

- ACS, 2 HST orbits, observing auroral H₂ Lyman & Werner bands
- Midnight oval not visible
- Relatively quiet aurora
- Dawn brightened, but variable over the interval, although total emitted power does not vary significantly.
NASA Infrared Telescope Facility - CSHELL

- 3 m telescope on Mauna Kea, Hawaii.
- CHSELL is a high resolution spectrograph (R ~ 35,000). 30” slit aligned East-West on the northern pole. Short wavelength coverage.
- Science products:
  - $H_3^+$ intensity
  - $H_3^+$ ion wind velocities across the polar cap
Telescope ‘wobble’ introduces significant errors on $\text{H}_3^+$ intensity and derived ionospheric velocities.
Keck II - NIRSPEC

• 10 m telescope on Mauna Kea, Hawaii.

• NIRSPEC is a high resolution spectrograph (R ~ 25,000). Cross dispersed - long wavelength coverage. Slit aligned North-South, traversing both poles.

• Science products:
  - H$_3^+$ Intensity (high S/N)
  - H$_3^+$ temperatures
Keck NIRSPEC

- Measure $H_3^+$ intensity along the north-south aligned slit, seeing both northern and southern aurora

- Initially, both midnight and noon oval visible on the north

- Southern aurora brightens around 12:00 UT

- Low latitude structures - ring rain? (O’Donoghue et al., 2013)
**Comparing hemispheres**

- Keck sees northern aurora brightest when largest max field aligned current (FAC) passes over northern noon.

- Keck sees southern aurora brightest about when southern max FAC is at noon.
2013-111 Cassini Geometry

- Cassini pointing ~fixed in local-time
Cassini UVIS

- Ultraviolet H, H$_2$ auroral emissions
- Main oval, varies slightly in latitude, at a minimum when the southern PPO phase $\sim 0^\circ$
- Discontinuity at 09:00 UT
- Diffuse equatorward emission below -70° latitude
• Infrared $\text{H}_3^+$ emissions at 3.5 micron

• ‘Well behaved’ auroral oval

• Discontinuity at noon at 09:14 UT - associated with the rotating electric field?

• NO diffuse equatorward emission as seen in the ultraviolet by UIVS. Is this regions cooler than the rest of the oval?
Multi-spectral comparison I

- General agreement with the main oval
- Differences in morphology mostly due to instrumental effects
• H Balmer-alpha emissions in the visible
• High spatial resolution at high cadence
• Fine structure within the main auroral oval
Multi-spectral comparison II

- Good correspondence in the three wavelengths of the main oval
- Emission visible in IR and UV not present in visible
- Fine structure seen in individual ISS images not present in this average view
Summary

• Good agreement on the location of the main oval in the infrared, visible, and ultraviolet

• Significant differences are present:
  ✤ Differences in emission mechanism
  ✤ Differences in how the instruments operate
  ✤ Differences in temperature?

• There is spatial variability on every resolution observed (tens of km upward)

• There is temporal variability on minutes, but also longer term over hours
IAU Longitude vs. PPO Longitude

- Are IAU longitudes (defined in the Voyager era) useful for showing features fixed relative to rotation?

Provan et al., (today)
Next: Nightside/dayside Temperatures

(a) view from Cassini

(b) view from the Earth

Keck

VIMS