Auroral emission at Jupiter through Juno's UVS eyes

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Juno's Instruments

Gravity Science
- Study Jupiter’s deep structure by mapping the planet’s gravity field and magnetic field

Microwave Radiometer
- Probe Jupiter’s deep atmosphere and measure how much water (and hence oxygen) is there

JEDI, JADE and Waves
- Sample electric fields, plasma waves and particles around Jupiter to determine how the magnetic field is connected to the atmosphere, and especially the auroras (northern and southern lights)

UVS and JIRAM
- Using ultraviolet and infrared cameras, take images of the atmosphere and auroras, including chemical fingerprints of the gases present

JunoCam
- Take spectacular close-up, color images

For more information:
missionjuno.swri.edu & www.nasa.gov/juno
The Juno UltraViolet Spectrograph on NASA's Juno Mission

3.3 Detector and Detector Electronics

The Juno-UVS detector configuration includes an XDL microchannel plate (MCP) detector scheme housed in a vacuum enclosure with a one-time opening door containing a UV-grade fused-silica window (for limited UV throughput during testing). The door was spring loaded for opening with a wax-pellet-type push actuator. The vacuum enclosure has a vacuum pump port and a small, highly polished region which functions as a zero-order reflector (directing zero-order light from the instrument grating into the zero-order trap on the side of the instrument housing). The vacuum enclosure also utilizes four female connectors for the anode signals, and two high-voltage (HV) connectors for the MCP and anode gap voltages.

The detector's MCP configuration uses a Z-stack that is cylindrically curved to match the 150-mm Rowland circle diameter to optimize spectral and spatial focus across the Juno-UVS bandpass. The detector electronics provide two stimulation pixels that can be turned on to check data throughput and acquisition modes without the need to apply high voltage to the MCP stack or to have light on the detector. The MCP pulse-height information is output as 5 bits, which, together with the 11 bits of spectral and 8 bits of spatial information, results in the 3-byte output for every photon. The input surface of the Z-stack is coated with an opaque photocathode of CsI (Siegmund 2000).

The detector array enhances the detection efficiency (DQE). Each of the three nested MCPs has a cylindrical 7.5-cm radius of curvature matching the instrument’s Rowland circle radius (i.e., 15.0 cm diameter). The approximate resistance per MCP plate is $\sim 130 \text{ M}\Omega$. The MCP forms 4.6 cm width in the spectral axis by 3.0 cm height in the spatial axis with 12-µm diameter pores and a length-to-diameter (L/D) ratio of 80:1 per plate. The XDL anode is a rectangular format of 4.4 cm $\times$ 3.0 cm. The combination anode array and MCP sizes gives an active array format of 3.5 cm $\times$ 1.8 cm necessary to capture the entire 68–210 nm instrument bandpass. The pixel readout format is 2048 pixels (spectral dimension) $\times$ 256 pixels (spatial dimension). The active area is 3.5 cm $\times$ 1.8 cm, with $\sim 1500$ spectral pixels and $\sim 230$ spatial pixels. The XDL anode uses two orthogonal UV light channels.
The Ultraviolet Spectrograph on NASA's Juno Mission

Fig. 4

An opto-mechanical schematic of the Juno-UVS sensor showing light rays traced through the main aperture door, reflecting from the OAP primary, passing through a focus at the slit, diffracted off the toroidal grating, and imaged onto the XDL MCP detector

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D. Grodent ULg
Slit projected onto XDL MCP detector

256 "pixels" (spatial) / 2048 pixels (spectral)

electronically digitized pixels
Slit projected onto XDL MCP detector
256 "pixels" (spatial) / 2048 pixels (spectral)

Toroidal diffraction grating

PSF < 0.6 nm

"Data Cube" (x, t, $\lambda$) Events List
Juno orbit
electronic (dark) noise when in/close to radiation belts
33 14-Day orbits

UVS segment: ~6 hours of continuous operations

Also near-apojove
UVS obs. (aurora ~few pixels)

UVS observes aurora < 2% of orbit
we need HST for the rest (> 98%) of the time
Juno is spin stabilized at 2 RPM: 1 rotation every 30 seconds in a plane containing the UVS boresight.

Use this rotation to scan the auroral region.
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2D map of HST aurora

⟹ Build 3D map

Use 143 maps accumulated for 10 sec (STIS ttag)

⟹ 4D

Build H₂ spectrum for each pixel

⟹ 5D

Extrapolate missing aurora

longitude (S3)

Simulate 3rd dimension with Chapman function \((z_0, H)\)
Start: 02 Nov 2016 15:00:04
End: 02 Nov 2016 15:10:34

Orbit #3

Altitude_{start} = 3.6 \text{ R}_J
Instantaneous spat. res. \sim 156 \text{ km} \times 893 \text{ km} / \text{pix}^2
Dark count rate \sim 216 \text{kC/s}

Aurora sitting on dayside terminator
(50\% night-50\% day)
1st HST frame

Dark counts

Daylight

Aurora

= 5 angles
= 5 rotations
= 5 x 30 sec
= 2 (1) angles
= 2 (1) rotations
= 2 (1) x 30 sec
10.5 min
Altitude_{start} = 2.04 R_J

Instantaneous spatial resolution $\sim 89 \text{ km} \times 509 \text{ km} / \text{pix}^2$

Dark count rate $\sim 6 \text{ kC/s}$

Aurora almost fully in nightside

Orbit #3

75 min later
= 5 angles
= 5 rotations
= 5 x 30 sec
= 2 (1) angles
= 2 (1) rotations
= 2 (1) x 30 sec
8 min
Altitude_{start} = 0.66 \text{R}_{J}

Instantaneous spat. res. \sim 29 \text{ km} \times 165 \text{ km} / \text{pix}^2

Dark count rate \sim 72 \text{kC/s}
Dark counts

= 7 angles
= 7 rotations
= 7 x 30 sec
4 min = 2 (1) angles = 2 (1) rotations = 2 (1) x 30 sec
Orbit #24

~ 10 months later

Aurora fully in nightside

S/C magnetic footprint on main emission

Altitude_{start} = 1.6 \, R_J

Instantaneous spat. res. \sim 70 \, \text{km} \times 397 \, \text{km} / \text{pix}^2

Dark count rate \sim 1112 \, \text{kC/s} \implies 40 \, \text{kC/s}
23 min

7 angles per 30 sec frame (should be 1 angle/frame)

Just 1 year to go!

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0.017 s