EPSC Abstracts
Vol. 11, EPSC2017-1004, 2017
European Planetary Science Congress 2017

Jovian aurora from Juno perijove passes: comparison of ultraviolet and infrared images

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1. Introduction

The electromagnetic radiation emitted by the Jovian aurora extends from the X-Rays presumably caused by heavy ion precipitation and electron bremsstrahlung to thermal infrared radiation resulting from enhanced heating by high-energy charged particles. Many observations have been made since the 1990s with the Hubble Space Telescope, which was able to image the H_2 Lyman and Werner bands that are directly excited by collisions of auroral electrons with H_2. Ground-based telescopes obtained spectra and images of the thermal H_3^+ emission produced by charge transfer between H_2^+ and H^+ ions and neutral H_2 molecules in the lower thermosphere. However, so far the geometry of the observations limited the coverage from Earth orbit and only one case of simultaneous UV and infrared emissions has been described in the literature. The Juno mission provides the unique advantage to observe both Jovian hemispheres simultaneously in the two wavelength regions simultaneously and offers a more global coverage with unprecedented spatial resolution. This was the case.

2. Observations

3. Two remote sensing instruments have collected images of the Jovian aurora during several perijove passes of the Juno spacecraft since August 27, 2016. The UltraViolet Spectrograph (UVS) covers the passband 70<λ<205 nm. UVS observes Jupiter for ~10 hours centered on closest approach. The Juno spacecraft spins at a rate of about 1 rotation every 30 seconds and the slit projection describes a series of swaths, which may be combined to generate global images of the UV aurora by integrating the count rate measured between selected wavelengths. As Juno approaches perijove, the spatial coverage decreases and the spatial resolution increases. A scan mirror with an amplitude of 30° may be used to modify the orientation of the line of sight perpendicular to the Juno spin plane and cover the full region of auroral emission in both hemispheres. Since UVS collects spectra covering both short wavelengths partly absorbed by hydrocarbon and longer wavelengths free of absorption, the combination of images makes it possible to construct map of the UV color ratio. This color ratio is considered as a proxy of the characteristic energy of the accelerated electrons producing the auroral H_2 emission. The Jovian Infrared Auroral Mapper (JIRAM) instrument includes two imager channels. One of them (L band) is centered at 3.455 μm and includes some of the bright H_3^+ auroral lines. As for UVS, images are acquired every 30 seconds, but the spatial resolution is significantly higher.

In addition, a spectrometer covering the 2-5 μm region at a mean spectral resolution of 9 nm may be used to simultaneously retrieve the H_3^+ column density and temperature and observed diffuse methane emission. Earlier observations have shown that the H_3^+ ro-vibrational spectrum has several bands in the range 3.0-5.0 μm. Best conditions for observation of the H_3^+ ions concentrate in the 3.2 to 4.0 μm spectral interval where the intense atmospheric methane absorption band minimizes solar and thermal radiation from the planet are low as a consequence of, resulting in a maximum auroral contrast against Jupiter's dark disk.

3. Infrared–ultraviolet comparison

Data were collected with both instruments during several perijove passes since August 2016, providing high spatial resolution of auroral structures. It is therefore possible to identify sequences when the two spectral imagers were operated simultaneously and observed the same auroral regions. We shall compare the morphology, brightness and time evolution in the two wavelength domains. Since the resolution of the two sets of images is different, the JIRAM images need to be adapted to the UVS pixel size for detailed comparison.

The H_2 emission is a prompt process resulting from collisions between the downward flux of energetic electrons and the major atmospheric constituent. By contrast, H_3^+ ions are produced by charge transfer from auroral-electron-produced H_2^+ and H^+ ions with neutral H_2 molecules. This IR emission is approximately thermal, so that the intensity of the outgoing radiation depends on both the column density of H_3^+ ions and the temperature distribution in the emitting region. We describe similarities and differences in the morphology and brightness distribution. The time evolution in the two spectral domains will be shown and interpreted in terms of energy of the auroral electrons, time history of the precipitation and lifetime of the H_3^+ ions. They will be complemented with UV color ratio maps that visualize the spatial distribution of the characteristic energy of the primary auroral electrons.

Acknowledgements

This research was funded by the PRODEX programme of the European Space Agency managed in collaboration with the Belgian Federal Science Policy Office (BELSPO). A.R. is supported by the Belgian Fund for Scientific Research (FNRS).