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Current-Voltage Relation View of Temporal/Spatial Variations of Jupiter Aurora: Hisaki and HST Comparison

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Abstract

We investigate the temporal and spatial variations of the Jupiter aurora applying the power and color ratio (CR) relations using both Hisaki and Hubble Space Telescope (HST) data. Spatially-resolved HST observation shows the relation is different among auroral regions. Spatially-integrated continuous observation by Hisaki indicates the occurrence rate of polar-like events, i.e., large CR and small power based on HST results, becomes large during low solar wind dynamic pressure. For the auroral power enhancement events, two scenarios are proposed in the view point of source plasma variations derived from the relation.

1. Introduction

Ultraviolet (UV) emissions are from atmospheric H_2 and H excited by precipitating auroral electrons. The far-UV (FUV) color ratio (CR), defined as the ratio of the intensity of a waveband unabsorbed by hydrocarbons to that of an absorbed one, is usually used to estimate the auroral electron energy. The previous study shows high latitude emissions additionally show cases of high electron energies (large CR) with low energy flux [1]. The spectrometer EXCEED [e.g., 2] onboard JAXA's Earth-orbiting planetary telescope Hisaki monitors extreme UV emissions from Jovian aurora and Io plasma torus continuously. Hisaki succeeded to detect sporadic, large auroral power enhancements lasting both short (<1 planetary rotation) and longer variations [3]. The latter is mostly accompanied with solar wind dynamic pressure enhancements. In this study, we investigate (1) the time variation of power-CR relation in these events and (2) statistical survey for occurrence of polar-dominant events, using Hisaki and HST data.

2. Datasets and Analysis

The HST observations (ID: GO13035) acquired FUV images and spectra of Jupiter's northern aurora using the FUV-MAMA detector of STIS. The long slit G140L grating provides imaging spectra over 1100–1700 Å with ~12 Å resolution (Fig. 1). The typical CR for STIS spectra is defined as $CR_{STIS} = I_{1550–1620\ Å} / I_{1230–1300\ Å}$, where I is the height-integrated intensity of the emission in units of kR or photons/sec. Power of $I_{1550–1620\ Å}$ is referred to as the auroral electron energy flux. 200 sec spectral observation is taken 14 times over the first 2 weeks on January 2014.

EXCEED counts photons over 800–1480 Å wavelength range with 3 Å resolution, over northern hemisphere (Fig. 1a). CR_{EXCEED} is newly defined as $CR_{EXCEED} = I_{1385–1448\ Å} / I_{1263–1300\ Å}$. The power representing energy flux is replaced by $I_{1385–1448\ Å}$. We used observation from 20 Dec. 2013 to Jan. 2014.

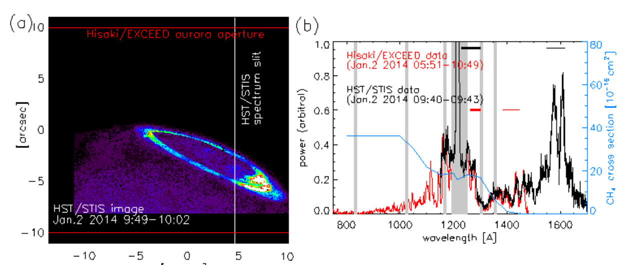

Figure 1. (a) HST auroral image and (b) auroral spectra taken by HST (black) and Hisaki (red).

3. Results

3.1 Power-CR Relation and Variation

The power-CR_{STIS} relation is derived from HST/STIS spectra separating regions, i.e., main aurora and polar region, referring to the images taken in the same HST orbit (Fig. 2a). As the previous study [1], CR increases with the power generally and the polar emission additionally contains low power and high CR components.

The power-CR_{EXCEED} relation for EXCEED (Fig. 2b) shows similar scatters, with large power and medium CR for intensity enhanced events [3] both short- (orange, <1 rotation) and long- (light blue) durations.

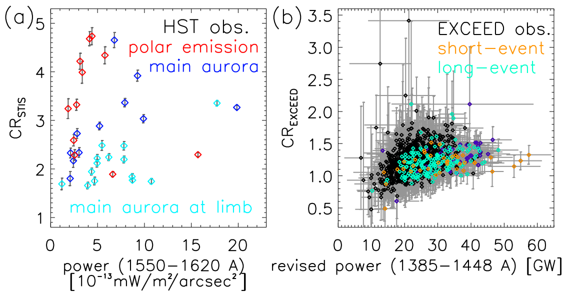

Figure 2. Power-CR relations derived using (a) HST and (b) Hisaki data, where the latter power is normalized by aperture.

3.2 Statistics of Polar-dominant Event

We select events with low power and large CR (Fig. 3a), which we take to represent events dominated by high latitude emission. These events are observed often at end of 2013 and Jan. ~10 (Fig. 3b). Solar wind pressure (blue line) and interplanetary magnetic field (IMF) sector (horizontal line for toward time) are estimated from the solar wind models [4, 5]. Occurrence of the polar-dominant events (orange & red) increases for low solar wind pressure period.

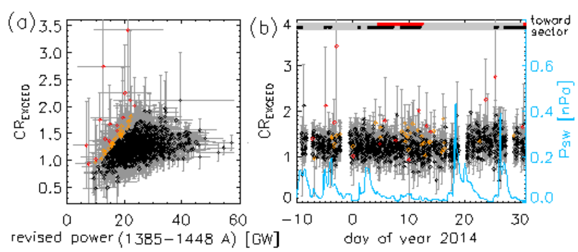

Figure 3. (a) Power-CR_{EXCEED} relation and (b) time variations of CR_{EXCEED}, solar wind dynamic pressure (blue line), and the IMF sector (horizontal bar).

4. Discussion

Time variation of the power-CR relation during auroral intensity enhancement events indicates source current density enhancements according to the Knight's auroral electron acceleration theory. Possible scenarios to explain the derived variations are (i) an adiabatic variation of the magnetospheric plasma under a magnetospheric compression and/or plasma injection, and (ii) a change of the dominant power of auroral components from the main aurora to the emission at the open-closed boundary.

Potential causes for these observed potential-dominant events are (i) enhancements of the polar emission, (ii) relative increases of the polar emission in the total emission by a decrease in the main auroral oval emission, and/or (iii) rising of the hydrocarbons in the atmosphere to increase the absorption effect and CR.

5. Conclusions

We derive power-CR relations using spatially-resolved HST data and continuous observation enabled by Hisaki. Characteristic power-CR relation of polar region, i.e., small power and large CR, is often observed during small solar wind dynamics pressure periods. The auroral intensity enhancements associated with flux enhancements, rather than the energy, indicates source current enhancements.

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