Development of Hyperspectral Camera for Aurora Imaging (HySCAI) ~Interdisciplinary application of visible spectrometer developed for magnetically confined plasma to astrophysical plasma~

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Visible spectrometer has been widely used as magnetically confined plasma diagnostics to measure various parameter (impurity concentration, ion temperature, magnetic field pith angle, isotope ratio, ion velocity space distribution function). The hyperspectral camera for auroral imaging (HySCAI), which can provide a two dimensional (2D) aurora image with full spectrum, was developed to study auroral physics as one of the interdisciplinary application to astrophysical plasma. HySCAI consists of an all-sky lens, monitor camera, galvanometer scanner, grating spectrograph, and electron-multiplying charge-coupled device (EM-CCD). The galvanometer scanner can scan a slit image of the spectrograph on the all-sky image plane in the direction perpendicular to the slit. HySCAI has two gratings; one is 500 grooves/mm for a wide spectral coverage of 400–800 nm with a spectral resolution (FWHM) of 2.1 nm, and the other is 1500 grooves/mm for a higher spectral resolution of 0.73 nm with a narrower spectral coverage of 123 nm. This system has been installed at the KEOPS (Kiruna Esrange Optical Platform Site) of the SSC (Swedish Space Corporation) in Kiruna, Sweden [1]. We estimated the precipitating electron energy from a ratio of I(630.0 nm)/I(427.8 nm) to be 1.6 keV at the auroral breakup [2].

A quantitative measurements of aurora emission during the astronomical twilight are difficult using the all-sky camera equipped with a bandpass filter, because of the contamination of background emission due to sunlight. In contrast, the HySCAI gives the precise aurora emission intensity by subtracting the background of the spectrum. The spectrum of high-altitude blue auroral emissions has been observed with HySCAI during morning astronomical twilight. Auroral resonance scattering of N_2^+ 1NG (0, 1) (427.8 nm) emission [3] starts to increase from the east at the bigging of astronomical twilight (03:07:22 UTC). Then, the increase of this resonance scattering emission extends to the magnetic zenith in the middle of astronomical twilight (03:43:22 UTC). The volume emission rate is evaluated from the rise in resonance scattering emission (time derivative of emission intensity). The volume emission rate of N_2^+ (427.8 nm) becomes maximum when the shadow height of the sunlight becomes 200 km, although the GLOW model [4] predicted the peak altitude of N_2^+ (427.8 nm) of 120 km (height). The higher altitude of the resonance scattering emission peak observed with HySCAI supports the idea that upflowing N_2^+ ions are responsible for the sunlit aurora, although we cannot rule out another possible mechanism: N_2^+ is produced by the charge exchange of O^+[5].

References

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