A plan of new spectroscopic and imaging observation of short-wavelength infrared aurora and airglow (1.05-1.35 μm) at Longyearbyen (78.1°N, 16.0°E) coordinated with EISCAT Svalbard radar

Takanori Nishiyama[1,2], Masato Kagitani[3], Senri Furutachi[4], Takuo Tsuda[4], Yuki Iwasa[5], Yasunobu Ogawa[1,2], Fuminori Tsuchiya[3], and Fred Sigernes[6]

[1]*National Institute of Polar Research, Japan*

[2]*Department of Polar Science, The Graduate University for Advanced Studies, SOKENDAI, Japan*

[3]*Planetary Plasma and Atmosphere Research Center, Tohoku University, Japan*

[4]*Department of Computer and Network Engineering, Cluster II, The University of Electro-Communications, Japan*

[5]*Research Institute for Physical Measurement, National Institute of Advanced Industrial Science and Technology, Japan*

[6]*Kjell Henriksen Observatory, The University Centre of Svalbard, Norway*

A new ground-based optical observation of aurora and airglow in short-wavelength infrared (SWIR) is being planned in Longyearbyen (78.1°N, 16.0°E) coordinated with EISCAT Svalbard Radar (ESR). Two state-of-the-art instruments, a SWIR imaging spectrograph and a monochromatic imager, have been developed to focus on study on dayside magnetosphere-ionosphere-atmosphere coupling processes in the high polar regions.

The 2-D imaging spectrograph, NIRAS-2, has a fast optical system and high spectral resolutions to challenge twilight/daytime aurora measurements from the ground. It is designed for SWIR wavelength from 1.05 to 1.35 microns in which sky background intensity is weaker than in visible. It covers strong auroral emissions in N_2^+ Meinel band (0-0) and N_2 1st Positive bands (1-2, and 0-1). Its field-of-view (FOV) and angular resolution are 55 degrees and 0.11 degrees per pixel, respectively. If a 30-microns slit is used, spectral bandpass around 1.1 microns are 0.53 nm and 0.21 nm with two different gratings (950 lpmm and 1500 lpmm). In a test observation, we successfully measured airglow emissions of OH (5,2), (6,3), (7,4), and (8,5) bands in 1.07-1.33 microns, and O_2 IR band at 1.27 μm. With the 1500-lpmm grating and a 60-m slit, each line in OH (5,2) band was spectrally resolved well. It should be noted that peak intensity of N_2^+ (0,0) band is about 10 times greater than that of OH (5,2) $P_1(3)$ line, and therefore we concluded that the spectrograph can detect aurora activities with sufficient time resolutions shorter than 30 seconds and allows us to investigate spatial and temporal variations associated with magnetosphere-ionosphere coupling and particle precipitations. For upper mesosphere, OH (8,5) band was measured with good quality, and rotational temperature can be estimated with 10-min resolutions and errors less than 3 K.

In addition to the NIRAS-2, we have been developing the brand-new SWIR camera, NIRAC, focusing on aurora emissions in N_2^+ (0-0) band. The camera consists of a few commercial SWIR lenses for security/defense purposes, plano-convex lenses, a custom optical filter (center: 1112.76 nm, FWHM: 13.8 nm) and an InGaAs FPA (640 × 512 pixels). Total optical system is fast (F1.5) and we examined that the point spread function is less than 5 pixels in full width at half maximum even near the end of the FPA. The FOV is 92 × 73 degrees and slightly wider than that of the spectrograph. In a test observation, we successfully identified horizontal structures of OH (5,2) band airglow layers with 30-seconds exposures.

Sensitivity of both the instruments was calibrated by light sources consists of two integrated spheres with different diameters (76-inch and 6-inch) in the following two steps. At first, using spatially uniform light with known spectrum emitted from a port (diameter less than 20 mm) of the small integrate sphere, we calibrated absolute sensitivity only in the centers of the FOVs. Next, light from the large integrate sphere, which can illuminate the whole FOVs, was used to calibration for non-uniform sensitivity within the FOVs caused by each optical system.

The instruments are going to be installed at The Kjell Henriksen Observatory/The University Centre in Svalbard (KHO/UNIS) in November 2022. Taking geographical advantage of the observatory, 24-hours continuous observations can be expected near the winter solstice. Observational study in conjunction with active/passive radio remote sensing, such as ESR and VLF/LF radio wave receivers, are also planned to precisely estimate energy flux of precipitating particles associated with aurora and sub-sequent changes in electron density and neutral/ion temperatures. We are going to address the following scientific goals: dayside reconnections and wave-particle interactions monitored by auroral emissions, ion upflow observed as enhancements of resonant scattering of N_2^+ ions, energetic particle precipitation impacts on OH chemistry in the upper mesosphere, atmospheric waves variability, and its connection to ionospheric disturbances in E-F regions. We will also discuss the observational strategies and future collaborations