Development of a near-infrared high-resolution Echelle spectrograph ESPRIT for planetary atmospheric observations

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We report the latest status of development of near-infrared spectrograph, ESPRIT (Echelle Spectrograph for Planetary Research In Tohoku university). This spectrograph is designed to be optimized for observations of near-infrared emission and absorption from planetary atmospheres and satellites. The emission and absorption in the infrared wavelength range have information of physical phenomena, such as the composition and density of the molecular species of the atmosphere, temperature and wind speed. Because of the high-resolution spectroscopic capability of ESPRIT, we can obtain the atmospheric velocity from the Doppler shift of the emission lines and the temperature from the intensity ratio of multiple emission lines. To understand the time and spatial variations in the various ranges, it is necessary to carry out long-term and flexible observations of planetary atmosphere with ground-based telescopes and planetary probes. Since an infrared high-resolution spectrograph is big and heavy, in most cases they are installed on medium- and large-class ground telescopes, and opportunities were limited with proposal-based operations. We will install ESPRIT on our 60 cm telescope (T60) at the summit of Haleakala (3040m), and achieve the monitoring measurement. Our main observation target is the infrared emissions in Jovian thermospheric H_3^+/H_2 aurora and airglow, and ESPRIT will be provided to wider users in observations of various targets including the lower cloud layer (around 2.3 um) and airglow (1.27 um) in Venus and H_2O and CO_2 atmosphere in Mars. We plan to install ESPRIT on T60 first, and in the future, we will install it on the 1.8 m off-axis telescope PLANETS.

ESPRIT can change an imaging mode and spectral mode with a long slit (length 50 arcsec). A slit viewer will be installed to monitor the position of slit on a planetary disk. We adopt the Raytheon InSb 256x256 array of which wavelength range is in the range of 1-4 um. The plate scale at the detector is 0.3 arcsec/pixel (field of view 76 arcsec) in the case of F12 incident light. The whole optical system is cooled down to 90 K with the radiation shield by using the He refrigerator, and the detector unit is cooled down to 35 K. For the spectral mode, the echelle grating (31.6 gr/mm, blaze angle 71 degrees, 29mmW x 136mmL x 20mmT) is used. This was selected so that the diffraction efficiency is greater than 0.8 at the wavelengths of Jovian H_3^+ emission (3.95 um), and H_2 emission (2.12 and 2.30 um). The resolution of spectrograph is R~20,000. The mechanism is used to change the grating angle from 62 to 80 degrees, and we can observe the 1.27, 2.12, 2.30, 3.41, and 3.95 um wavelength bands (wavelength coverage $1.0\times10^{-3}\lambda$) by this mechanism. with an angle stability of 1 arcsec/5min (corresponding to a Doppler velocity of 0.5 km/s in Jovian auroral emission). This stability was verified by previous tests. When ESPRIT is installed to T60 and we set the slit the polar aurora emissions in the east-west direction, we estimate that this data can be obtained for every 3 min (SNR~15), and the intensity distribution in Jovian polar region with 5-10 frames can be acquired in about 1 hour. This time resolution would be sufficient to clarify the time variations of disturbances in the magnetosphere and ionosphere, as well as the coupling processes between ions and neutral winds in Jovian thermosphere.

In the present situation, we almost completed the fabrication of mechanical and optical systems, such as the echelle grating mechanism, filter turret, slit-imaging change mechanism, collimating and camera mirrors, grating and other components. We will manufacture the heat path and the cooling box for the detector. Further, we will perform the electrical tests of the detector using the driving and read-out

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electronics and software under vacuum and cooling conditions. We plan to install the detector unit to ESPRIT by this June, and start the integration test of ESPRIT from July.

Keywords: near-infrared spectrograph, planet, high-resolution spectrograph

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