

Development of the near-infrared camera TOPICS and the Echelle spectrograph ESPRIT for planetary observations

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We are developing a near-infrared imager TOPICS (Tohoku Planetary near-Infrared Camera System) and echelle spectrograph ESPRIT (Echelle Spectrometer for Planetary Research In Tohoku University) to carry out long-term observations of variations in planetary and satellite atmospheres at Haleakala Observatory (3,055 m) in Hawaii. In this study, we improved the electronics of the InSb 256 x 256 array by developing a proper and safe driving system of TOPICS, and conducted the vacuum and cooling tests of ESPRIT.

We summarized the results of TOPICS as follows. (1) Development of the precise ammeter: We developed the precise ammeter circuits with two specifications in the range of $\pm 500 \mu\text{A}$ with the resolution of $\sim 0.0209 \mu\text{A}$, and in the range of $\pm 10 \text{ mA}$ with the resolution of $\sim 0.418 \mu\text{A}$. These ammeters were combined with the driving and readout electronics. Measuring with the science grade detector (Raytheon, SCA#108), we obtained current values as estimated for the all lines. These values are used as references in the future safe operation. (2) Development of voltage input sequence control system. We developed the electronics that control the turn on and turn off sequence of voltages to the detector using logic device and analog switches. (3) Test with the engineer grade detector (Raytheon, SCA#060): We got similar images of a halogen lamp to that in the previous tests by using a bandpass filter (a center wavelength is $2.295 \mu\text{m}$). Therefore, we verified proper work of the new electronics. (4) Test with science-grade detector: We got the images of halogen lamp successfully. However, dark current was high ($2,230 \text{ e}^-/\text{s}$) and the read noise was also huge ($1,730 \text{ e}^-_{\text{rms}}$). We require the dark current less than $40 \text{ e}^-/\text{s}$, and the read noise less than $60 \text{ e}^-_{\text{rms}}$ to observe Jovian thermospheric ion wind velocity with an accuracy of $\pm 0.5 \text{ km}$ from Doppler shift of the emission line of the Jovian H_3^+ aurora. We found that the main noise source is the pre-amplifier, and will improve it soon. For the dark current, we found that the detector temperature was 47 K of which optimal temperature is 30-35K.

We summarized the updates of ESPRIT (wavelength range 1–4 μm , wavelength resolution 20,000) as follows. (5) Vacuum test: We carried out vacuum and leak tests of ESPRIT chamber with optical system. The vacuum level reached to be 2.47×10^{-7} Torr which is sufficient for this spectrograph. (6) Development of thermal path: Thermal paths between 1st and 2nd stages of He refrigerator, radiation shield, and cold plate on which the detector is mounted. The thermal paths are made of oxygen-free copper mesh (wire diameter: $\phi 0.23 \text{ mm}$, density: 50 mesh/inch). We found that the temperature of radiation shield and internal optical system reached to be 96 K, and cold plate to be 14 K which satisfies temperature requirements.

We will reduce the dark and read noises of TOPICS soon, and plan to install it on the T60 telescope at Haleakala. The electronics of ESPRIT is similar to that of TOPICS, and we are ready to develop the electronics for ESPRIT.

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