Engineering first light of a new mid-infrared instrument MIMIZUKU

*Takafumi Kamizuka[1], Takashi Miyata[1], Shigeyuki Sako[1], Ryou Ohsawa[1], Masahito S. Uchiyama[1], Tomohiro Mori[1], Yutaka Yoshida[1]

1. Institute of Astronomy, School of Science, the University of Tokyo

The University of Tokyo is currently constructing an observatory, the University of Tokyo Atacama Observatory (TAO), in the Atacama Desert in Chile. The site is located at the summit of Cerro Chajnantor, whose altitude is 5640 m. The high altitude and the dry climate decrease the water vapor in the atmosphere (Precipitable Water Vapor <0.5 mm) and improve the atmospheric transmittance in the infrared region. Therefore, the site is one of the most ideal places for infrared observations on the ground. By placing a large-aperture telescope (6.5 m in diameter) at the site, we make the TAO a cutting-edge facility for infrared observational astronomy. The Mid-Infrared Multi-field Imager for gaZing at the UnKnown Universe (MIMIZUKU) is the first-generation mid-infrared instrument for the TAO. The main features of MIMIZUKU are: 1) wide wavelength coverage from 2 to 38 microns, 2) high-spatial resolution, and 3) accurate calibration of the atmospheric absorption. The wide wavelength coverage is achieved by installing three optical channels, NIR, MIR-S, and MIR-L, covering 2.0-5.3, 6.8-26, and 24-38 microns, respectively. Each channel can perform imaging and low-resolution spectroscopic observations. The high spatial resolution is achieved by the large-aperture telescope, which determines diffraction-limited spatial resolution. The calibration accuracy of the atmospheric absorption is improved by installing a special optical device called Field Stacker. The Field Stacker has three movable mirrors and is placed on the telescope focal plane. The mirrors pick off the light from two sky regions and combines them into one field. Then, we can observe two different sky regions simultaneously. By using this function, we can perform simultaneous observations of scientific target and reference object. Simultaneous observations allow us to compensate the time variation of the atmospheric absorption and improve accuracy of its calibration. If this function successfully works, we can realize stable and accurate observations even in wavelength regions with low atmospheric transmittance, like ozone absorption region around 9.6 microns and long-wavelength mid-infrared regions in >20 microns.

Ahead of the completion of the TAO, planned around late-2020, engineering observations of MIMIZUKU were carried out at the Subaru telescope in July and December, 2018. In these observations, the functions of the MIR-S channel and the Field Stacker device were tested. As for the imaging functions, the spatial resolutions in the N- and Q-bands were confirmed to be 0.32 and 0.59 arcsec, respectively. It means that MIMIZUKU can achieve diffraction-limited images in the mid-infrared regions. As for the spectroscopic functions, spectral resolutions for the N- and Q-band modes were measured to be 180 and 100, respectively. These are consistent with the designed values. In addition, the effectiveness of the Field Stacker on the calibration of the atmospheric absorption were also confirmed. It was found that we can reduce the photometric uncertainty to a few percent even under the condition where the photometric count varies with >10 % (p-v) due to the atmospheric variation. As for the spectroscopy, Q-band spectroscopic observations, which have been difficult in ground-based observations, were realized. We found that the atmospheric absorption can be calibrated with the Field Stacker and that we can get spectra in 17-24.5 microns with fluctuations less than 5%.

These capabilities enable us to perform wide-wavelength spectroscopic monitoring observations. Such observations are useful to investigate time variation of temperature and amount of dust produced by dust-forming events around evolved stars like red giants and supernovae. In this presentation, we will report the results of the engineering observations and future prospects of the observational studies on dust formation process using MIMIZUKU.

Keywords: Ground mid-infrared observations, Monitoring observations, Dust formation, The University of Tokyo Atacama Observatory (TAO), MIMIZUKU