Development of the Mid-Infrared Data-Reduction Method without Chopping using COMICS Archive Data

Ryou Ohsawa
Institute of Astronomy, University of Tokyo

Atmospheric Emission

A detector receives the emission from objects, a telescope, and the atmosphere. The variations in the emission from the object and telescope are negligible. The atmospheric emission is assumed to be uniform in the field of view. The pixel of the detector at \((i,j)\) receives the signal given by

\[ I_{i,j}(t) = f_{i,j} E_{\text{sky}}(t) + G_{i,j}, \]

where \(f_{i,j}\) is the flat frame, \(E_{\text{sky}}(t)\) is the emission of the atmosphere, and \(G_{i,j}\) is the summation of the other emission.

In the chopping observation, the beam is changed in such a frequency that \(E_{\text{sky}}(t)\) can be regarded as constant, which is typically \(\approx 1\) Hz. It is impossible to oscillate a secondary mirror of large telescopes such as TMT in this high frequency.

Proposed Method

Instead of high frequency chopping, we develop a method to estimate \(f_{i,j}\). Let \(\langle X \rangle\) and \(X\) the averages of \(X\) in the spatial and time domains, respectively. Let \(\langle f_{i,j}\rangle = I\), and the equation above is written as

\[ I_{i,j}(t) - I_{i,j} = f_{i,j} \langle I(t) \rangle - \langle I \rangle. \]

This equation indicates that \(I_{i,j}(t) - I_{i,j}\) is expected to have a linear dependence on \(\langle I(t) \rangle - \langle I \rangle\) with the slope of \(f_{i,j}\). Figure 1 demonstrates the linear relationship between \(I_{i,j}(t) - I_{i,j}\) and \(\langle I(t) \rangle - \langle I \rangle\) with archival data obtained with COMICS.

Assuming \(E_{\text{sky}}(t)\) is almost uniform in the field of view, the flux variation between the time \(t\) and \(t'\) can be estimated by multiplying \(f_{i,j}\).

The images reduced by our method are shown in Figures 2 and 3.

Summary & Future Work

We develop a new method for data reduction for ground-based mid-infrared observations. As shown in Figures 2 and 3, our method drastically reduces the beam-switching frequency required to subtract the atmospheric emission. There are many things to be done toward practical use of the proposed method: The instabilities of the flat frame and fluctuations in the telescope's temperature should be investigated, and the practical performance remains to be evaluated. It, however, has a potential to enable dithering observations in the mid-infrared. The proposed method can make an important step toward the mid-infrared observations with TMT.