A millimeter-wave spectrometer equipped with a new frequency multiplexer for simultaneous multi-line observation

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Ground-based microwave spectroscopy provides vertical mixing profiles of minor constituents in the middle atmosphere both in day and night, but only one or two molecular species are observable at a time by an ordinary ground-based microwave instrument. That is mainly because the frequency separations between different molecular species are larger than the instantaneous frequency band width of the backend spectrometer. In addition, contamination from the image-band frequency of the heterodyne mixer-receiver makes the issue complicated. We have developed a new waveguide-type frequency multiplexer that divides a common input signal between 170 and 260 GHz into 4 distinct frequency bands. The following heterodyne mixers convert the spectral frequencies down to the same IF band by adjusting the LO frequency configuration of the mixer, then we can obtain more than 4 spectra with one backend spectrometer.

The multiplexer is based on a novel technique of waveguide image-band rejection filters (IBRF) (Asayama et al., 2015). The IBRF consists of a quadrature hybrid coupler and band-pass filter (BPF). The pass-band frequency of the BPF is adjusted to the first target molecular spectrum, and the target spectral signal is outputted through the BPF. The quadrature hybrid coupler followed by the BPF works as a backward separator which isolates the forward input signal and the backward stop-band reflection signal from the BPF at different ports. Since the leakage of backward reflection wave into the input port generates a standing wave that distorts the proper spectral line shape, the isolation between the input and output ports is essentially important. The reflected signal from the 1st IBRF is transferred to the 2nd IBRF whose pass-band frequency is adjusted to the second target molecule. The frequency multiplexer is composed of series connections of IBRFs in this way.

The detailed structure and dimensions of the quadrature hybrid coupler and the BPF sections are designed by using HFSS (High Frequency Electromagnetic Field Simulator) to provide 4 output frequency ports at 179 - 187 GHz, 199 - 207 GHz, 226 - 234 GHz, and 246 - 254 GHz. These frequency bands are assigned to observe water vapor, water vaper isotope, CO, O_3, and NO_x simultaneously to study the ion-chemistry initiated energetic particle precipitations (EPPs), photo-chemistry, and the effect of atmospheric transport in the polar regions. We plan to assemble the full spectrometer system within two years and install it at Syowa Station.

Key words: microwave, ground-based, spectrometer

References

Asayama, S. et al. 2015: *J. Infrared Milli. Terahz Waves*, **36**, 445-454.