A New Terahertz Emission Spectrometer at RIKEN

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In radioastronomy, rotational emission lines of molecules are extensively observed to investigate physical and chemical structures of target sources. For secure identification of molecules and accurate analyses of Doppler shifts caused by overall/internal motions of the target sources, accurate rest frequencies of molecular transitions are indispensable. Rest frequencies of various molecules have been measured by spectroscopic studies in the laboratory, and are tabulated in the spectral line catalogs with the aid of extrapolation based on spectroscopic data analyses. However, their accuracies are sometimes insufficient for identification of molecules and detailed discussions of the velocity structure of the sources, which causes serious limitation and uncertainty in astrophysical and astrochemical interpretations. Hence, it is important to measure rest frequencies of the transitions used for astronomical observations directly by the laboratory spectroscopy. Such an effort is more and more important in the ALMA era, because even faint rotational spectral lines of various isotopic species as well as those in vibrationally excited states, which have not been well studied in the laboratory, are readily observed, thanks to high sensitivity of ALMA.

With this in mind, we are constructing a new laboratory THz emission spectrometer at RIKEN. A block diagram of the spectrometer is shown in Figure 1. We measure the emission of rotational transitions of molecules in the 2 m long glass cell by using the superconducting hot electron bolometer (HEB) mixer receiver, which has been developed for the THz astronomical observations [1]. The HEB mixer is mounted on the ALMA-type cartridge receiver system. The THz emission from the molecule is down-converted to the 1.0-1.6 GHz range, and is frequency-analyzed by the XFFTS spectrometer with the spectral resolution of 0.8 MHz. We are now assembling the components toward test measurements. At this moment, the frequency coverage is limited to 0.8 THz-0.9 THz and 1.3-1.5 THz. We are planning to extend it to the lower frequencies by employing the SIS mixer receivers.

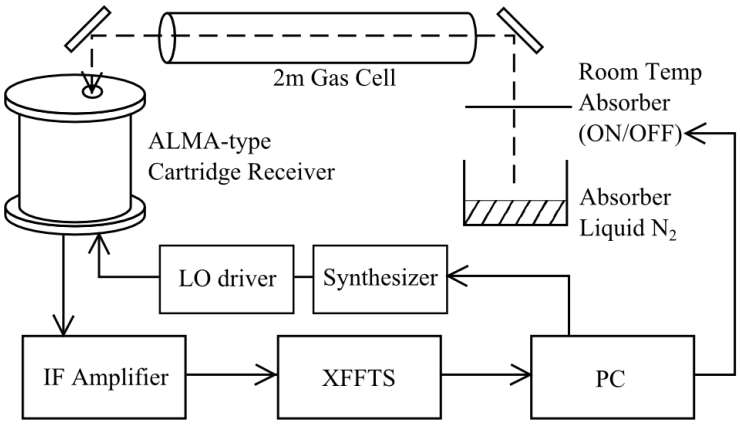

Figure 1: The block diagram of the spectrometer at RIKEN

References

[1] T. Soma, "Development of the HEB receiver for ground-based THz astronomical observations", PhD thesis, The University of Tokyo, 2015