Development of Terahertz Superconductive HEB Mixers and Its Application to Molecular Spectroscopy

M. Takegahara,[1] Y. Ebisawa,[1] Y. Watanabe,[2] N. Sakai,[3] Y. Oya,[1] and S. Yamamoto[1]
[1]*Department of Physics, The University of Tokyo, Japan*
[2]*Department of Physics, University of Tsukuba, Japan*
[3]*RIKEN Cluster for Pioneering Research, Japan*

Observations of abundances of fundamental atoms and molecules as well as their distribution are very important for exploring the chemical evolution in star-forming regions. Since some of them have emission lines in the THz band, we are developing a superconductive HEB (Hot Electron Bolometer) mixer as a heterodyne device to observe those lines. In fabrication of the HEB mixer, AlN is applied as a buffer layer, since it is known to help improvement of the critical temperature for the NbTiN superconducting film. But its effect on the performance of the HEB Mixers was unknown. Hence, we prepared the HEB mixers with and without the AlN buffer layer, and compared their performances. As a result, the noise temperature of the mixers with AlN is found to be improved by 0.32 dB on average compared with ones without buffer layer.

Then, we employed the fabricated HEB mixer for spectroscopic studies in the 0.9 THz band in the laboratory. A 10.8 nm-thick NbTiN film is used as the superconducting material of the HEB mixer, and the width of the superconducting microbridge is 0.2 μm. A 20 nm-thick AlN buffer layer is applied. This HEB mixer is mounted on the ALMA type cartridge receiver of the emission spectrometer (SUMIRE) at RIKEN (Figure 1). With this spectrometer, we observed the HDO (1_{11}-0_{00}: 893.638666 GHz), HDO (2_{02}-1_{01}: 919.310885 GHz), D_2O (2_{12}-1_{01}; 897.947107 GHz) and methanol (894.614183 GHz) lines. Examples of the observed spectra are shown in Figure 2. In this experiment, we notice that the lines show some unexpected and strange line shapes. A reason for such a feature is now under consideration.

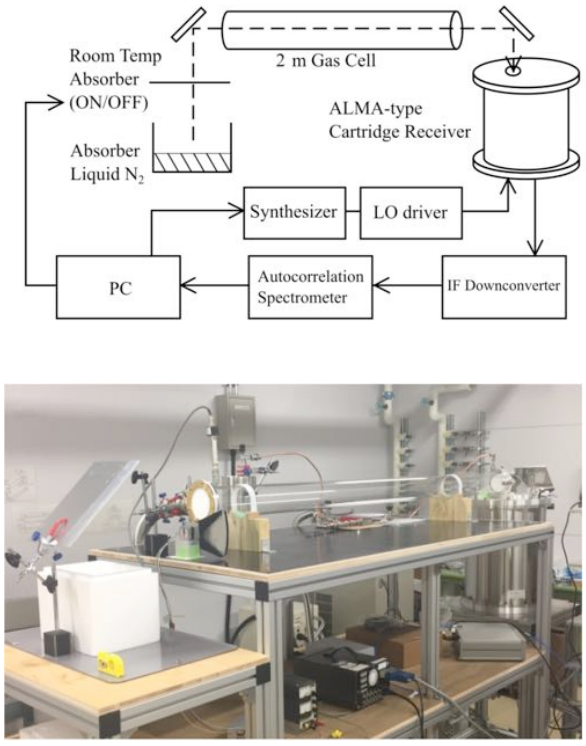

Figure1: Emission spectrometer at RIKEN (SUMIRE)

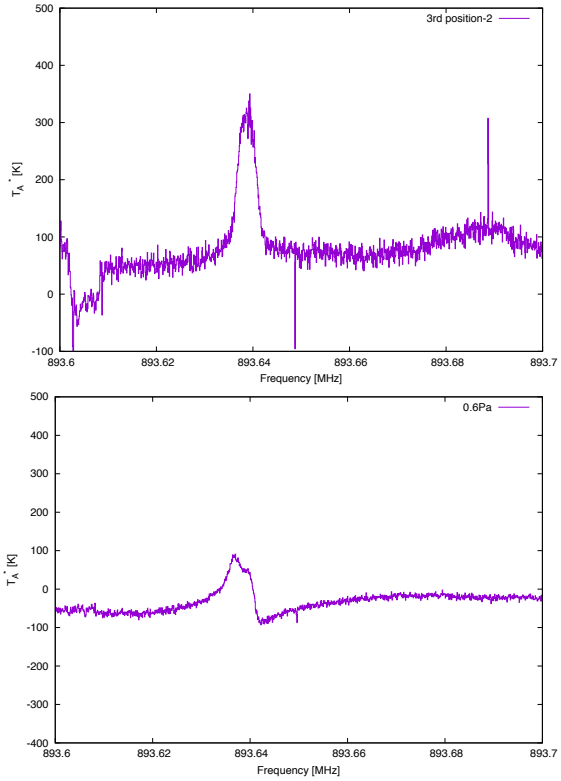

Figure 2: Spectra of the HDO (1_{11}-0_{00}) transition