# DOUBLE MODULATION SUB-MILLIMETER WAVE SPECTROSCOPY OF IONS

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Sub-millimeter spectra are detected in almost all cases by using source frequency modulation technique. The sensitivity is often limited by background distortion intrinsic to the source frequency modulation. The background can be subtracted and corrected numerically. In some cases, it could be corrected for by taking the difference between the spectra recorded with, for example, discharge on and off or with supersonic molecular beam on and off. A double modulation method will enable us to do such correction automatically and more effectively.

Double modulation scheme employed in this work is a combination of frequency modulation and magnetic field modulation. A similar technique was used for observation of a weak millimeter wave line of oxygen in the excited vibrational state using frequency-Zeeman modulation[a], and more recently Hirahara, Tanigawa, and Kawaguchi[b] employed a frequency-discharge double modulation. In the present investigation, molecular ions are generated in an extended negative glow discharge cell with an axial magnetic field of about 200 gauss. Therefore, by switching the magnetic field, the ion concentration is modulated. The source frequency modulation frequency is 10 kHz and magnetic field is switched on and off at a frequency of 11 Hz. Two lock-in amplifiers are used in series. The first one demodulates the higher frequency component and the lower modulation frequency is set to fall within the pass-band of the first lock-in amplifier. The output from the first lock-in is fed to the second one.

With this method, the lines of $HOC^+$, isotopic species of $HCO^+$ and $HN_2^+$, the vibrational excited lines of these ions and $H_2COH^+$ in the frequency range of 520-680 GHz with a BWO as a radiation source are measured. The sub-millimeter wave frequency is phase-locked to harmonics of a millimeter wave radiation from a phase-locked Gunn oscillator. These measurements provide more accurate transition frequencies and the improved molecular constants which are useful for submillimeter wave astronomy.

[a] T. Amano and E. Hirota, J. Mol. Spectrosc. 53, 346(1974)

[b] Y. Hirahara, N. Tanigawa, and K. Kawaguchi, paper 4PA65, Symposium on Molecular Structure, Nagoya, October 1997