Development of Cavity Enhanced Absorption Spectrometer Aiming to Measure Optical Absorption Bands of Interstellar Molecules

I. Fukuda,[1] T. Sato,[1] M. Araki,[1] T. Oyama,[2] S. Hoshino,[1] K. Tsukiyama[1]

[1]*Faculty of Science Division I, Tokyo University of Science, Japan*
[2]*RIKEN, Japan*

Diffuse Interstellar Bands (DIBs) are mysterious unidentified absorption bands detected optically in diffuse clouds. DIBs are presumed to be electronic transitions of large organic molecules. Identification of their origins allows us to unveil a wide variety of chemical composition of space, because approximately 600 DIBs have been found so far [1]. However, at present only the five bands were assigned to the fullerene cation C_{60}^+ [2] and the other bands are not identified yet.

To reveal DIB carriers, comparative studies of astronomically observed bands with laboratory spectra are required. However, a covering range of a high-resolution laboratory spectrometer is generally narrow, although DIBs disperse over a wide range. A wide-band spectrometer can be a powerful tool to identify these bands.

Cavity enhanced absorption spectroscopy is possible to widely measure a high-resolution spectrum [3]. This method enables us to achieve a very long optical path length, because white light introduced in between two high reflectivity mirrors reciprocates more than ten thousand times. Based on these advantages, this spectrometer is suitable to measure DIB-candidate molecules produced in laboratory. In this study, we developed this spectrometer that simultaneously covers the 60-nm range by using the 1200 lines/mm grating. As a demonstration of sensitivity, the fifth CH stretching overtones ($v' = 6$) of methyl acetate (a) and ethyl acetate (b) were detected for the first time, as shown in Fig. 1. Additionally, we also detected methanol produced via saponification of methyl acetate by sodium hydroxide (c3). As a next step, we plan to install a hollow-cathode discharge system to produce DIB-candidate ion and radical of large organic molecule.

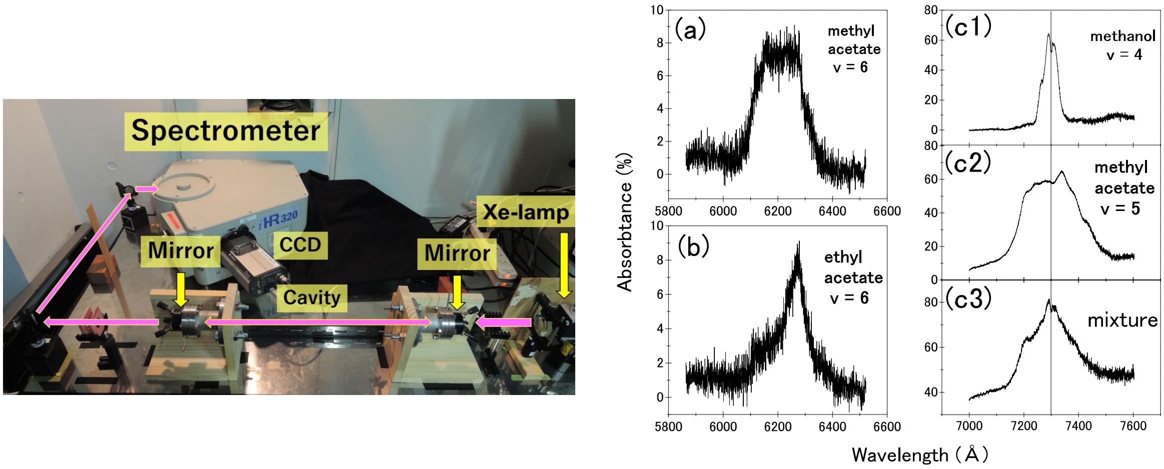

Figure 1: Cavity-enhanced absorption spectrometer (left) and the observed spectra. (a) $v' = 6$ of methyl acetate. (b) $v' = 6$ of ethyl acetate. (c1) $v' = 4$ of pure methanol. (c2) $v' = 5$ of pure methyl acetate. (c3) mixture of methyl acetate with methanol produced by saponification of methyl acetate. The sample pressure was adjusted in the range of 0.020 – 156 Torr depending on the peak intensities.

References

[1] e.g., Fan et al. 2019, ApJ, **878**, 151.
[2] Campbell et al. 2015, Nature, **523**, 322
[3] Oyama & Araki, 2020, J. Spectrosc. Soc. Jpn., **69**, 144.