Developments of Optical Spectrometers as Approaches to Diffuse Interstellar Bands

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The diffuse interstellar bands (DIBs) were first discovered in the optical absorption spectra on stars in 1922. Although several hundreds DIBs were detected already, DIBs still remain the longest standing unsolved problem in spectroscopy. It has not been known that what kind molecules have these absorptions. One of the best approaches to identify DIBs can be the following procedure: 1) a generation of a DIBs candidate molecule in laboratory, 2) measurements of laboratory frequencies of electronic transitions of the molecule, and 3) comparisons between the laboratory frequencies and astronomically observed DIBs spectra.

To be able to solve the DIBs problem, we have been developed a discharge-emission spectrometer. A hollow cathode was used to generate molecular ions in a discharge, since it has been suggested that molecular ions can be probable DIBs candidates. The discharge was produced by a pulsed voltage of 1500V. A wide wavelength range of this spectrometer was covered by a monochromator HORIBA Jobin Yvon iHR320 (the 200-800 nm wavelength range using three gratings having groove densities 1200 and 1800 gr/mm). The dispersed discharge-emission was detected by a photomultiplier and recorded via a lock-in amplifier. Recently the $^2E_2$–X^2B_3 electronic transition of the butatriene cation $H_2CCCCH_2^+$ was observed in the discharge emission by using 2-butyne CH_3CCCH_3 as shown in Figure 1. The frequency of the electronic transition was measured to be 20380 cm^{-1}, which make a study of a comparison with the observed DIBs spectrum.

Although the above spectrometer can cover the wide wavelength range, the resolution is insufficient to have an accurate comparison between the laboratory frequencies and astronomically observed DIBs spectra. Since DIBs are absorption, an absorption spectrum in laboratory is better suited for the comparison. To obtain a high-resolution absorption spectrum, a cavity ringdown spectrometer using the same hollow cathode is under development.

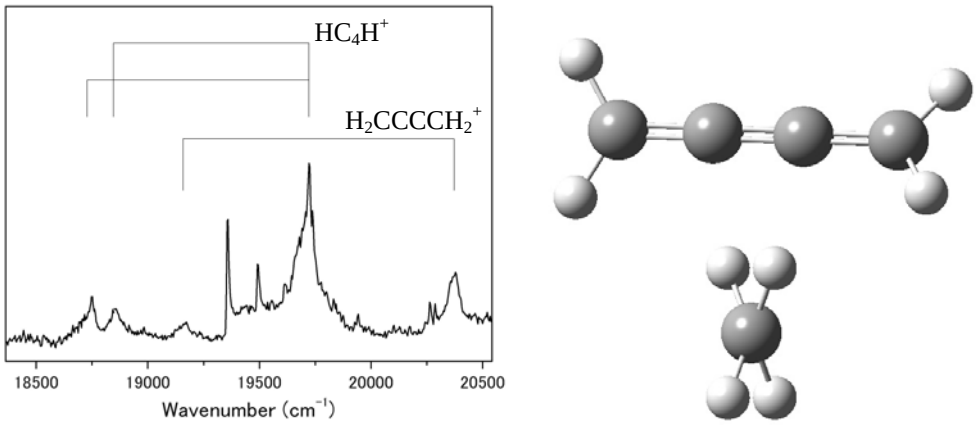

Figure 1: Emission Spectrum of $H_2CCCCH_2^+$ observed by the discharge-emission spectrometer (left) and the molecular structure of H_2CCCCH_2 (right).