Study of CH_3CN in Diffuse Clouds by "Hot Axis Effect"

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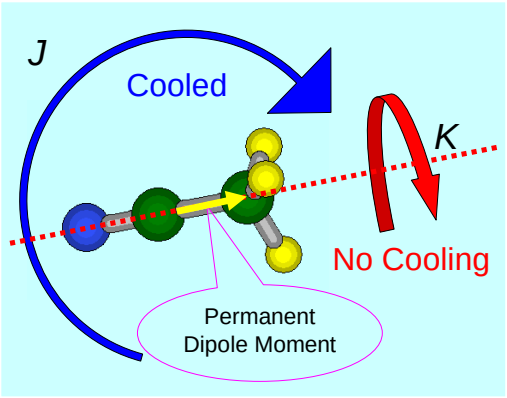
The diffuse interstellar bands (DIBs) are optical absorption lines by molecules in diffuse clouds. Initially observed more than 100 years ago, they still remain the longest standing unsolved problem in spectroscopy and astrochemistry, although five DIBs have recently been identified as due to fullerene ion C_{60}^+ [1]. Identifications of DIBs are important because they can give us information on chemical composition in diffuse clouds. To further identify carrier molecules of DIBs we have measured DIB candidate molecules produced in the laboratory to compare their absorption spectra with astronomically observed DIB spectra. In this work, we first present our latest results on the search for the thiophenoxy radical C_6H_5S, benzene derivative, by using our cavity ringdown spectrometer [2]. We then present a new insight into diffuse clouds. Molecules in diffuse clouds are collisionally heated and radiatively cooled. In diffuse clouds the latter is dominant. Due to the spectroscopic selection rules, acetonitrile CH_3CN is cooled well for the end-over-end rotation but is not cooled for rotation around its molecular axis, as shown in Figure 1. We made a model of this non-thermal rotation as "Hot Axis Effect." Based on this model, we estimated a rotational absorption spectrum of CH_3CN in the radio frequency region. By using Nobeyama 45 m radio telescope, the absorption lines were searched in the diffuse clouds in front of the Orion IRc2 region and the radio continuum source B0212+735 quasar. The upper limits of column densities of CH_3CN toward Orion IRc2 and B0212+735 were determined to be 2×10^{12} and 2×10^{13} cm^{-2}, respectively. On the other hand, a possible absorption feature, as a disturbed feature around the K = 3, 2, 1, and 0 lines, by Hot-axis effect for CH_3CN was found in the spectrum toward Sgr B2 in the reported line survey data [3], as shown in Figure 2.



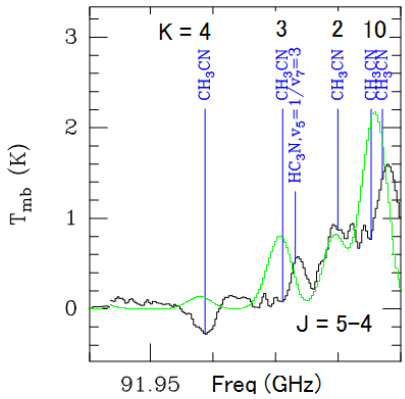


Figure 1 (Left): Hot-axis effect for a symmetric-top molecule. The red dotted line is the hot-axis.
Figure 2 (Right): Absorption feature of K = 4 and a disturbed feature around the K = 3, 2, 1, and 0 lines by Hot-axis effect for CH_3CN in the spectrum of Ref. [3]. The black line is an observed profile, and green a mode one.

References

[1] Campbell et al., 2015, Nature 523, 322, Walker et al., 2015, ApJ 812, L8, Campbell et al., 2016, ApJ 822, 17.
[2] Araki et al., 2014, ApJ 148, 87. [3] Belloche et al., 2013, A&A 559, 47.