High-resolution and high-accuracy infrared spectra of interstellar methylamine in the gas phase

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The study of the rotational and vibrational spectra of molecules in the interstellar medium is particularly useful to elucidate the physical conditions and chemical contents and evolutions of these interstellar gases. The spectrsocopic study of methylamine (CH_3NH_2) in the laboratory has been directly led to the valuable application to the detection of CH_3NH_2 earlier in 1974 [1] and recently in 2011 [2] in the Universe. In fact, the spectra of CH_3NH_2 are rich and highly crowded due to the two coupled large-amplitude internal motions of torsion and inversion which can be caused in collisions with He and H_2 in a molecular cloud. Furthermore, the Universe has a very wide range of astrophysical sources, and the astrophysical observations now are increased in resolution and in sensitivity by ALMA (Atacama Large Millimeter Array), HIFI (Heterodyne Instrument for the Far Infrared), and FAST (Five-hundred-meter Aperture Spherical radio Telescope), which greatly need more and precisely expanded laboratory databases of CH_3NH_2. However, since the first report about seventy years ago at low resolution of 1 cm^{-1} and an accuracy of about 0.1 cm^{-1} [3], the high-accuracy infrared spectra in the C−N vibrationally stretching band of CH_3NH_2 have just recently been studied by the technique of Lamb-dip saturated absorption spectrum by us for just a set of 43 saturation dips primarily in the C−N stretching *Q*-branch region in only two sub-states [4]. Currently, we have systematically expanded our sub-Doppler measurement to this band of gaseous CH_3NH_2 over a wider range of transitions in *P*-, *Q*-, and *R*-branch. More than 200 Lamb-dip signals in 27 sub-states have been observed individually at a spectral resolution of 0.4 MHz and the transition frequencies of them have been determined with an accuracy of ±0.1 MHz. Our current experimental results constitute a high-accuracy spectral database in the important 9−11 micrometer region for various theoretical and experimental studies and applications to CH_3NH_2 for astrophysical and astrochemical communities.

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