TERAHERTZ SPECTROSCOPY AND GLOBAL ANALYSIS OF THE BENDING VIBRATIONS OF $^{12}C_2H_2$ and $^{12}C_2D_2$

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Symmetric molecules have no permanent dipole moment and are undetectable by rotational spectroscopy. Their interstellar observations have previously been limited to mid-infrared vibration-rotation spectroscopy. Although relatively weak, vibrational difference bands provide a means for detection of non polar molecules by terahertz techniques with microwave precision. Herschel, SOFIA, and ALMA have the potential to identify a number of difference bands of light symmetric species, e.g., C_2H_2, CH_4 and C_3. This paper reports the results of the laboratory study on $^{12}C_2H_2$ and $^{12}C_2D_2$. The symmetric isotopomers of acetylene have two bending modes, the trans bending ν_4 ($^1\pi_g$), and the cis bending ν_5 ($^1\pi_u$). For $^{12}C_2H_2$, the two bending modes occur at 612 and 729 cm^{-1}, respectively. For $^{12}C_2D_2$, the two bending modes occur at 511 and 538 cm^{-1}. The ν_5-ν_4 difference bands are allowed and occur in the microwave, terahertz, and far-infrared wavelengths, with band origins at 117 cm^{-1} (3500 GHz) for $^{12}C_2H_2$ and 27 cm^{-1} (900 GHz) for $^{12}C_2D_2$.

Two hundred and fifty-one $^{12}C_2D_2$ transitions, which are from ν_5-ν_4, (ν_5+ν_4)-2ν_4 and 2ν_5-(ν_5+ν_4) bands, have been measured in the 0.2-1.6 THz region, and 202 of them were observed for the first time. The precision of these measurements is estimated to be from 50 kHz to 100 kHz. A multistate analysis was carried out for the bending vibrational modes ν_4 and ν_5 of $^{12}C_2D_2$, which includes the lines observed in this work and prior microwave, far-infrared and infrared data on the pure bending levels. Significantly improved molecular parameters were obtained for $^{12}C_2D_2$ by adding the new measurements to the old data set which had only 10 lines with microwave measurement precision. The experiments on $^{12}C_2H_2$ are in progress and ten P branch lines have been observed. We will present the $^{12}C_2H_2$ results to date.