SUBMILLIMETER-WAVE SPECTRUM OF CH$_2$D$^+$

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In interstellar carbon chemistry, CH$_2^+$ is thought to be an important and abundant molecular ion. However, as it is a symmetric planar molecule and, as a result, it has no permanent dipole moment, it is almost impossible to detect this species by radio astronomical observations. Its deuterated species, CH$_2$D$^+$ and CHD$_2^+$, possess the dipole moment, so the rotational lines should be observable. Röslein et al.$^a$ and Jagod et al.$^b$ observed the infrared spectra of these deuterated species. Demuyneck and coworkers$^c$ tried to observe CH$_2$D$^+$ rotational lines in an extended negative glow discharge with no success. More recently Lis et al.$^d$ reported tentative identification of CH$_2$D$^+$ toward Ori IRe2.

The molecular constants and the predicted rotational transition frequencies given by Röslein et al.$^a$ were a good starting point in searching for the rotational lines. A very weak feature was found almost exactly at the calculated frequency for the $2_{12} - 1_{11}$ transition. Eventually the line appeared stronger enough for precise frequency measurements, after adjusting the reaction conditions. The optimum gas mixture was found to be CH$_4$ ($\sim 3$ mTorr), CD$_4$ ($\sim 1$ mTorr), H$_2$ ($\sim 2$ mTorr), and He ($\sim 35$ mTorr). It is interesting to note that helium is essential to produce CH$_2$D$^+$. No signals were detectable with Ar buffer. Although the signal was seen without H$_2$, it appears to play a subtle role in the formation, resulting in about a factor 2 increase in intensity. Adding D$_2$ instead of CD$_4$ resulted in no signal. The observations were made with about 16 mA discharge current with liquid nitrogen cooling. As this ion is a light molecule and the signal was only weakly observed, four transitions were detected so far in the 280-890 GHz region. All observed transition frequencies agree within 1 MHz of the predicted frequencies. These laboratory transition frequencies strongly support the tentative astronomical identification by Lis et al.$^d$

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$^b$M.-F. Jagod et al., J. Mol. Spectrosc. 153, 666 (1992)
$^d$D. C. Lis et al., in Submillimeter Astrophysics and Technology ASP Conference Series, 417, 23 (2009)