THE $J = 1 \leftarrow 0$ ROTATIONAL TRANSITIONS OF $^{12}CH^+$, $^{13}CH^+$ and $^{12}CD^+$

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The CH^+ ion is the first molecular ion identified in interstellar space. Dunham[a] detected a couple of unidentified lines in near-UV, and later Douglas and Herzberg[b] identified them based on their laboratory observations. The electronic spectra have been investigated extensively. On the other hand, the pure rotational transitions are less extensively studied. Cernicharo *et al*[c] reported the interstellar detection of the J=2-1, 3-2, and 4-3 transitions in NGC 7027. Pearson and Drouin[d] reported the laboratory observation of the J=1-0 line of $^{12}CH^+$ at 835078.950 MHz and, based on this frequency, predicted the frequencies for $^{13}CH^+$ and CD^+. The predicted $^{13}CH^+$ frequency led to identification of the interstellar line[e]. In this talk, we present a new set of measurements of the J=1-0 lines for the normal species together with the ^{13}C and D isotopic species. The overwhelming evidences obtained in our experiments support the new identifications.

An extended negative glow discharge in a gas mixture of CH_4 ($\sim$ 0.5 mTorr) diluted in He ($\sim$ 60 mTorr) was used for production of CH^+ with the discharge current of about 15 mA. Axial magnetic filed up to 160 Gauss was applied. The normal species line exhibited a surprisingly large Zeeman splitting for a $^1\Sigma$ molecule. The $^{13}CH^+$ line showed the spin-rotation hyperfine splitting, and at higher field of 150 Gauss an unresolved lineshape was exhibited due to combined hfs and Zeeman splittings. The spin-rotation splitting in the normal species was negligibly small. The CD^+ line showed much smaller Zeeman and spin-rotation splittings, as expected. Details of the mechanism to induce such Zeeman effect and the spin-rotation interaction will be presented. The transition frequencies for these $J = 1 - 0$ lines are: 835137.498(20) MHz and 453521.847(20) MHz for $^{12}CH^+$ and CD^+, respectively. The transition frequencies for $^{13}CH^+$ are 830216.680(50) MHz ($F = 3/2 - 1/2$) and 830214.961(50) MHz ($F = 1/2 - 1/2$). The uncertainties reflect possible errors in correcting the Zeeman shifts.

[a] T. Dunham, *Publ. Astron. Soc. Pac.*, **49**, 26 (1937)
[b] A. E. Douglas and G. Herzberg, *Astrophys. J.* **94**, 381 (1941)
[c] J. Cernicharo *et al.*, *Astrophys. J.*, **483**, L65 (1997)
[d] J. C. Pearson and B. J. Drouin, *Astrophys. J.*, **647**, L83 (2006)
[e] E. Falgarone *et al.*, *Astrophys. J.*, **634**, L49 (2005)