THE INFRARED SPECTRUM OF CH$_5^+$

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Protonated methane, CH$_5^+$, has unusual C-H bondings and is a new prototype of spectroscopic specimen. While all of the five protons are strongly bound to the central carbon atom with well defined C-H stretch potentials, angles between C-H bonds are highly fluxional. Ab initio theory predicts lowest energy for an "equilibrium structure" with C$_g$ symmetry but the barriers separating the 24 equivalent structures are extremely low and almost non-existent when zero point vibrations are taken into account.$^{ab}$ We have identified nearly 1000 spectral lines of CH$_5^+$ in a liquid N$_2$-cooled hydrogen dominated plasma using a gas mixture of H$_2$:CH$_4$ $\sim$ 100:1.$^c$ The spectral lines are weak and do not show obvious symmetry or regular pattern. The identification required extensive studies of the spectra of other carbocations CH$_n^+$ (and CH$_2^+$) and C$_2$H$_m^+$ (and C$_3$H$_n^+$) whose spectra appear in the same wavelength region with much higher intensities. Spectroscopy and plasma chemistry of those carbocations will be discussed and the raw observed spectrum of CH$_5^+$ will be presented without assignment nor even qualitative understanding.