The Detection of a MM-Wave Transition of Methlacetylene

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In May of 1971, we detected the $5_0 \rightarrow 4_0$ transition of CH_3CCH in emission in the galactic center source Sgr B2. This molecule is similar to cyanoacetylene and is a product of synthesis reactions producing complex hydrocarbons. The line was detected using the NRAO 36-foot telescope in Tucson, Arizona and a 3-mm mixer radiometer with a system temperature of 4000°K. At this wavelength the antenna has a beamwidth of 70" and the spectral line receiver has a resolution of 2 MHz (Buhl and Snyder, 1971).

The line spectrum is shown in Figure 1. The center velocity is +60 km/sec with a velocity width of 20 km/sec. The antenna temperature is estimated to be 0.3 ± 0.2K. There is no evidence of the K=1 or K=2 transition which should be shifted 1.6 MHz (6 km/s) and 6.5 MHz (23 km/s) to the right. The K=1 line may be blended with the K=0 line.

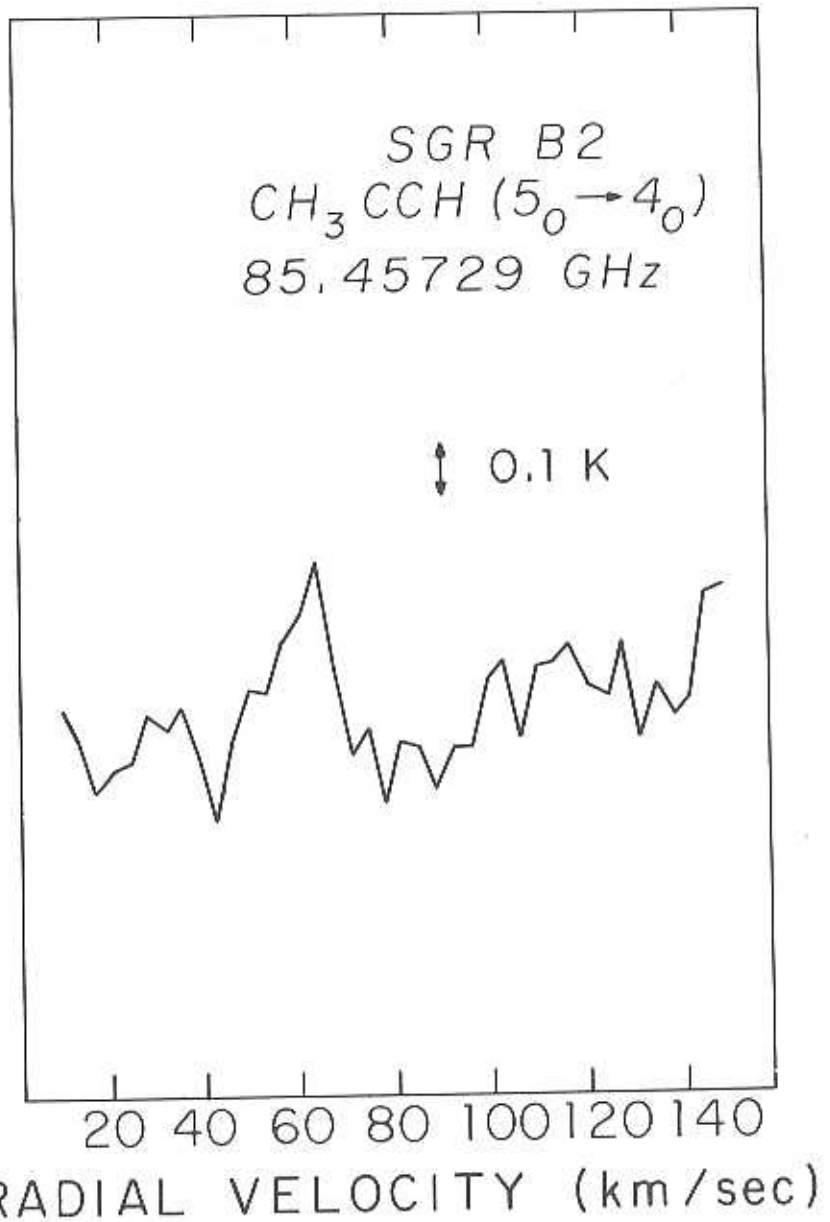
Attempts have been made to search for the first two levels of this molecule without success. The $1_0 \rightarrow 0_0$ transition at 17.092 GHz was looked for by Dickinson and Papadopoulos using the Haystack antenna, and the $2_0 \rightarrow 1_0$ at 34.183 GHz was search for by Schwartz and Zuckerman using the Naval Research Laboratory antenna. The problem with detecting these levels is that the larger beamwidth at these wavelengths dilutes the line. In addition, the line strength is directly proportional to the transition frequency and the principal quantum number J. These two effects favor the mm-wave transitions of the molecule ($J > 2$).

The 5_0 level is 8 cm^{-1} above the ground state and would be populated at temperatures $\geqslant$ 10 K. Hence, for most reasonable interstellar temperatures the molecule will be excited up to at least J=5. If the excitation is approximately thermal the $5_0 - 4_0$ transition at 85.457 GHz will be about 15 times the intensity of the ground state $1_0 - 0_0$ transition. This is illustrated in Figure 2 where the line intensity relative to the ground state is plotted against excitation temperature for several transitions. The intensity increases as one goes to higher level transitions and toward higher excitation temperatures.

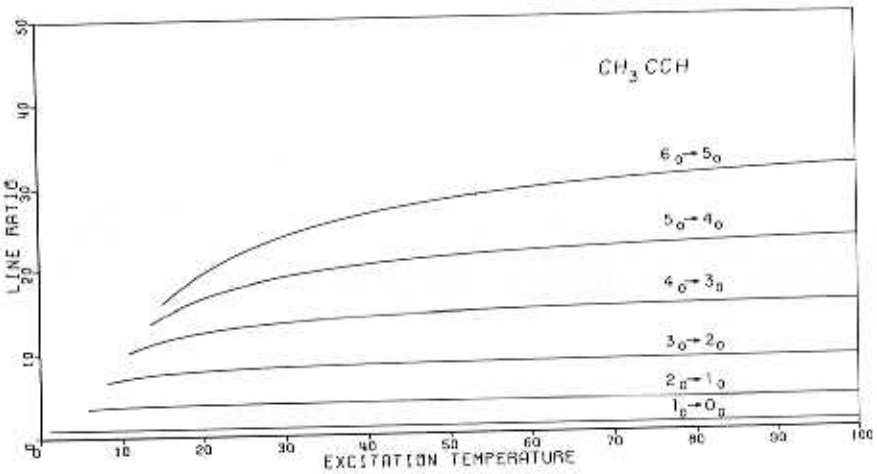
The line ratio for the $5_0 - 4_0$ transition (Figure 2) does not change much for temperatures above 20°K. However, as the principal quantum number J increases, the slope of the curve also increases giving a greater change in line ratio with temperature. This means that the higher levels ($J>6$), in addition to being more intense, are more sensitive to changes in excitation temperature and therefore will be more accurate as interstellar thermometers.

The lower level transitions (1_0-0_0 and 2_0-1_0) will be much weaker. The intensities predicted from Figure 2 would be .02°K and .06°K, probably below the limit of sensitivity for current receivers. Thus the two negative results mentioned earlier are understandable.

The implication of these results is that the excitation of the methyl acetylene molecule is reasonably thermal. Any inversion of the ground state would be



1. 3.5-mm line of methyl acetylene as seen in Sgr B2. Only the 5_0-4_0 transition is evident; however, it could be blended with the 5_1-4_1.



2. Predicted line strengths relative to the ground state for K=0 transitions of methyl-acetylene. Calculation is based on thermal excitation of the molecule.

easily detectable. Similar conclusions can be drawn from observations of the HNCO and OCS molecules (Buhl and Snyder 1972). The large organic molecules generally have quite a number of states below 20 cm^{-1} which will be excited. Thermal excitation should make the higher J transitions more intense. Measurements of a number of these transtions should give us a better picture of the excitation environment in which these molecules are imbedded.

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REFERENCES

Buhl, D. and Snyder, L. E., 1971, *Nature*, 232, 161.
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