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What Constitutes Spectroscopic Proof for the Detection of Large Hot-Core Molecules?

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Abstract. The presence of large organic species in interstellar gas has important implications for the origin of life and pre-biotic chemistry. Accurate identifications of such molecules, however, is problematic in molecular clouds. There are many reasons for such difficulties. One is that the spectral density is very high in objects where the chemistry is sufficiently complex to produce such species - at least 10 lines per 100 MHz in Sgr B2(N), for example, at 3 mm, at a sensitivity of 10 mK, peak-to-peak. Hence, the possibility of chance coincidences is large. Another reason is the presence of many large organic molecules at relatively high temperatures; these large asymmetric tops have vast numbers of favorable transitions under these conditions, including those originating from low-lying vibrational states. Confusion and blending of transitions of one large molecule with those of another add to the risks of an inaccurate identification.

A case in point is that of glycolaldehyde, CH_2OHCHO. In order to confirm the identification of this molecule in Sgr B2(N), we searched for its most favorable transitions in the 2 and 3 mm windows, spanning the energy range of ≈10-100 K - a total of 43 individual transitions. Of all these lines, only eight were not heavily blended or contaminated by other molecules, i.e. so-called "clean" features. Emission, however, was visibly detected at 34 of the other transitions, but for one transition, was clearly absent. The "missing" line corresponds to a weak transition originating in the $K_a = 3$ ladder, and its absence is consistent with the other detected features. Based on the clean features only, glycolaldehyde has a $V_{LSR} = 61.7 \pm 1.5$ km/s and $\Delta V_{1/2} = 7.8 \pm 1.8$ km/s with intensities consistently in the range $T_R^* \approx$ 20-70 mK. Given these data, the identification of glycolaldehyde is 99.9% secure. A rotational diagram from this data set yields a column density of $N_{tot} \approx 6 \times 10^{13}$ cm^{-2} for CH_2OHCHO - roughly a factor of 27 less than that of H_2CO. These data illustrate the problems and subtleties in identifying large organic molecules in space. These results will be discussed in context with other claimed identifications.

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