ISOTOPE RATIOS IN INTERSTELLAR FORMALDEHYDE

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Formaldehyde is an excellent molecule for studying isotopic abundances. It is easily observed in several connected transitions, allowing an analysis of excitation differences among species. With formaldehyde, one can also measure the same ratio using millimeter emission lines and centimeter absorption lines, which can often be interpreted more directly. A comparison of the results from the millimeter and centimeter lines can give an idea of the uncertainties in the analysis of millimeter emission lines.

There have been direct comparisons of 6-cm absorption of continuum sources by H_2CO and by $H_2{}^{13}CO$, but such measurements are subject to error because of photon trapping in the H_2CO, resulting in different excitations for the two species. This problem does not exist when comparing $H_2{}^{13}CO$ with $H_2C^{18}O$, for which the millimeter lines are optically thin; a direct comparison of 6-cm absorptions should give a good abundance ratio. In the first such measurement, Gardner et al. (1971) found a value of about 10 for this double ratio, compared to the terrestrial value of 5.6. We have reported (Tucker et al. 1979) more extensive $H_2C^{18}O$ observations, which, when compared with published $H_2{}^{13}CO$ spectra, suggested a ratio of about 6.9 for Sgr A, Sgr B2 and W33, with no significant source-to-source variation. Our results, using the NRAO[1] 43-m telescope, are supported by the observations of Henkel et al. (1979b) on the 100-m telescope.

To extend our observations, we have used the 43-m telescope to observe the ^{13}C species in all sources for which we have ^{18}O data. This provides us with data taken on the same system for the comparison. (We have also reobserved the ^{18}O species in Sgr B2 as a check.) The combined results of our observations are summarized in the table below, which gives the $H_2{}^{13}CO/H_2C^{18}O$ abundance ratio computed in two ways: (1) just using peak line optical depths, correcting for the effect of the large hyperfine splitting in the ^{13}C species (in the narrow line sources) and (2) using the integrated line optical depths. (Uncertainties are 1 σ and pointing is in the direction of the continuum peak in each source.)

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Source	$H_2{}^{13}CO/H_2C^{18}O$ Abundance Ratio Peak	Integrated	$^{12}C/^{13}C$
Sgr A	8.1 ± 1.5	8.3 ± 1.2	60 ± 9
Sgr B2	6.5 ± 0.6	6.5 ± 0.3	77 ± 4
W 33	7.5 ± 1.5	6.3 ± 0.8	79 ± 10
W 51	5.6 ± 1.8	5.2 ± 0.8	96 ± 15
NGC 2024	> 6.6	-	< 75

We believe that the integrated profiles are more meaningful despite the fact that they are somewhat more susceptible to baseline uncertainties. Besides the obvious statistical improvement from utilizing the whole line, using integrated intensities eliminates large corrections for the hyperfine structure in the ^{13}C species. Such corrections can be uncertain in sources with multiple peaks. The last column of the table gives the carbon isotope ratio, assuming a terrestrial oxygen ratio and no fractionation. These values are only slightly lower than the terrestrial value of 89, and are consistent with results obtained from 6-cm studies of H_2CO and $H_2{}^{13}CO$, when corrected for trapping, as described by Henkel et al. (1979a), and with the 2-mm observations of OMC-1 by Kutner et al. (1976).

Independent of assumptions of the oxygen ratio, our results yield a double ratio significantly closer to the terrestrial value than that obtained from CO (e.g. Wannier et al. 1976), but in agreement with the results for HCO^+ (Guélin and Thaddeus 1979; Langer et al. 1978). More analysis is required to see the extent to which molecule-to-molecule differences can be explained by fractionation. Until this is done, interpretation of the CO results as being representative of the interstellar medium may be premature.

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