

MOLECULAR ABUNDANCES IN G1.6-0.025

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G1.6-0.025 is a dense molecular cloud, located near the Galactic Centre at $l=1.6^\circ$ and $b=-0.025^\circ$. Lacking in star-forming or infra-red regions, the cloud was first detected as a prominent 5-GHz H_2CO absorption feature (Whiteoak & Gardner 1979). NH_3 observations by Gardner et al (1985) revealed a clumpy cloud with a diameter of about 30 parsec, average LSR velocity of 50 km s^{-1} , and a kinetic temperature exceeding 50 K. In addition, a high-velocity component at 160 km s^{-1} has been detected towards one of the clumps (Gardner & Boes 1987). CH_3OH in the cloud gives rise to a 12-GHz 2_0-3_{-1} E transition in absorption, representing the best example of rare population 'anti-inversion' for this transition (Whiteoak & Peng 1989; Peng & Whiteoak 1993). In contrast, the 36-GHz $4_{-1}-3_0$ E transition shows extended emission with superimposed knots containing maser emission (Haschick & Baan, 1993). Sobolev (1996) has suggested that a collision! has occurred between the main cloud and another cloudlet with relative velocity of 100 km s^{-1} , resulting in high kinetic temperatures and shock waves that create the CH_3OH masers.

In view of the unusual nature of G1.6-0.025, we have carried out a 3-mm molecular line study of it using the 22-m 'Mopra' antenna of the Australia Telescope (operated by the Australia Telescope National Facility, CSIRO).

The observations were obtained at frequencies between 86 and 115 GHz during several runs between 1995 June and 1996 September. A SIS

(superconductor-insulator-superconductor) receiving system provided single-sideband receiver temperatures which varied somewhat systematically with frequency between 80 and 130 K. At the observing frequencies the reflecting surface of the antenna has an effective diameter of 15 m, resulting in a half-power beamwidth ranging from 57 arcsec to 45 arcsec. All observations were made at RA(1950) = 17h46m12.0s Dec(1950) = -27o33'15", where the ^{13}CO emission near 50 km s^{-1} maximizes and the high-velocity emission is present. Periodic observations of SiO masers with well-established positions provided a pointing accuracy believed to be better than 15 arcsec. The spectra were obtained with a digital correlator; a combination of 1024 correlator channels and 64 MHz bandwidth provided a velocity resolution varying between 0.44 and 0.32 km s^{-1} after Hanning smoothing, for the above frequency range. The observing cycle consisted of pairs of on-source and off-source observations. Intensity calibration was carried out in a two-step process (Hunt et al. 1997). The observed intensities were first corrected for atmospheric attenuation using observations of an ambient temperature load. They were then transformed to a corrected antenna temperature " T_{MB} " scale by comparing the results for the sources Orion A and M17 SW with standard values given for spectra obtained with the Swedish-ESO Sub-millimetre Telescope (SEST).

Spectra were obtained for 16 transitions. In almost all, two broad emission features are centered near 60 and 160 km s^{-1} . In most cases the 60-km s^{-1} feature clearly shows two separate velocity components. Unconstrained two-component Gaussian fitting yielded components at median velocities of 45 and 60 km s^{-1} , with an uncertainty of 5 km s^{-1} . All transitions appear in emission except the 107-GHz transition of CH_3OH , for which all three velocity components appear in absorption. Many transitions have similar relative intensities for all three velocity components. The most outstanding differences are for the 45 km s^{-1} component. This velocity component has enhanced relative C_3H_2 emission, and enhanced 107-GHz CH_3OH absorption.

Table 1 lists the transitions and individual results for the three velocity components. Velocity-integrated line intensities and parameters (kinetic temperature and molecular hydrogen density) derived for the three clouds have been used to calculate excitation temperatures, column densities for the lower transition levels, and total column densities. The ^{12}CO and C^{18}O transitions were used to estimate the kinetic temperatures and hydrogen densities for the three clouds. Both transitions are assumed to be thermalised, and in LTE, implying that the excitation temperature for all levels is equal to the cloud kinetic temperature. The ^{12}CO emission was assumed to be optically thick and the C^{18}O emission optically thin; the observed low relative intensities support these assumptions. Given the excitation temper-

ature, it was possible to estimate the $C^{18}O$ $J = 1-0$ optical depth, the total $C^{18}O$ column density, and then H_2 column density from a ratio! nshi p quoted by Rohlfs & Wilson, (1996). Interestingly, the H_2 column derived from ^{12}CO gave similar results. An assumption of spherical symmetry for the cloud clumps yielded H_2 densities.

For several linear molecules, preliminary estimates of column density have been calculated from an LTE analysis of single transitions following standard methods (see eg. Blake et al. 1987). It is assumed that the observed emission is optically thin, and that the populations of all levels are characterised by a single excitation temperature. For OCS and HC_3N , with more than one observed transition, 'rotation' diagrams (e.g. Cummins et al. 1986) were used to estimate excitation temperatures. Assumed values are shown in parenthesis.

Compared with molecular abundances relative to hydrogen reported for the molecular clouds of OMC-1, Sgr B2 and TMC-1 our values appear to be generally lower. However, we stress that our results are preliminary, with large uncertainties. For instance, the three transitions of HC_3N give estimates of the total population which are spread over an order of magnitude; the assumptions of LTE and low optical depth may not be correct for this molecule, and this may also apply to other molecules. We are currently undertaking an LVG analysis of our observations, which should provide more accurate estimates.

References

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TABLE 1. Caption text

Molecule	Transition	Frequency (GHz)	T_{ex} (K)	Int T_{mb} Kkms ⁻¹	N(lower) cm ⁻²	N(total) cm ⁻²
45 kms ⁻¹ : $T_{kin} =$ 18.2K; $N(H_2) =$ 4 x 10 ²² cm ⁻² $n(H_2) =$ 3 x 10 ³ cm ⁻³						
CO	1-0	115.3	18	144.5	1.8E+16	1.3E+17
13CO	1-0	110.2	18	50.6	6.5E+15	5.0E+16
C18O	1-0	109.8	18	8.3	1.1E+15	8.1E+15
HC3N	10-9	91.0	6	35.9	9.6E+12	2.9E+14
HC3N	11-10	100.1	6	18.9	4.7E+12	2.4E+14
HC3N	12-11	109.2	6	12.3	3.2E+11	3.2E+13
OCS	7-6	85.1	10	22.3	1.7E+14	1.5E+15
OCS	9-8	109.5	10	19.4	1.2E+14	1.7E+15
CS	2-1	98.0	10	27.5	1.5E+13	5.8E+13
HCN	1-0	88.6	4	62.8	1.4E+13	3.0E+13
HNC	1-0	90.7	10	60.1	1.3E+13	6.5E+13
HCO+	1-0	89.2	10	4.3	7.9E+11	4.1E+12
60 kms ⁻¹ : $T_{kin} =$ 38.5K; $N(H_2) =$ 2 x 10 ²³ cm ⁻² $n(H_2) =$ 6 x 10 ³ cm ⁻³						
CO	1-0	115.3	38	726.3	9.0E+16	1.4E+18
13CO	1-0	110.2	38	88.7	1.1E+16	1.8E+17
C18O	1-0	109.8	38	23.1	3.0E+15	4.8E+16
HC3N	10-9	91.0	8	19.5	5.2E+12	1.0E+14
HC3N	11-10	100.1	8	33.7	8.3E+12	2.4E+14
HC3N	12-11	109.2	8	10.5	2.8E+11	1.2E+13
OCS	7-6	85.1	4	44.2	3.4E+14	6.2E+15
OCS	9-8	109.5	4	9.8	5.9E+13	5.8E+15
CS	2-1	98.0	4	78.0	4.2E+13	9.1E+13
HCN	1-0	88.6	10	165.9	3.7E+13	2.0E+14
HNC	1-0	90.7	4	118.4	2.5E+13	5.1E+13
HCO+	1-0	89.2	4	51.6	9.4E+12	2.0E+13
160 kms ⁻¹ : $T_{kin} =$ 31.8K; $N(H_2) =$ 3 x 10 ²³ cm ⁻² $n(H_2) =$ 5 x 10 ³ cm ⁻³						
CO	1-0	115.3	32	1003.2	1.2E+17	1.6E+18
13CO	1-0	110.2	32	147.9	1.9E+16	2.6E+17
C18O	1-0	109.8	32	54.3	6.9E+15	9.4E+16
HC3N	10-9	91.0	19	57.0	1.5E+13	2.0E+14
HC3N	11-10	100.1	19	48.1	1.2E+13	1.7E+14
HC3N	12-11	109.2	19	60.1	1.6E+12	2.6E+13
OCS	7-6	85.1	8	49.8	3.8E+14	3.5E+15
OCS	9-8	109.5	8	32.2	1.9E+14	3.6E+15
CS	2-1	98.0	8	74.2	4.0E+13	1.3E+14
HCN	1-0	88.6	8	135.6	3.1E+13	1.3E+14
HNC	1-0	90.7	8	71.0	1.5E+13	6.1E+13