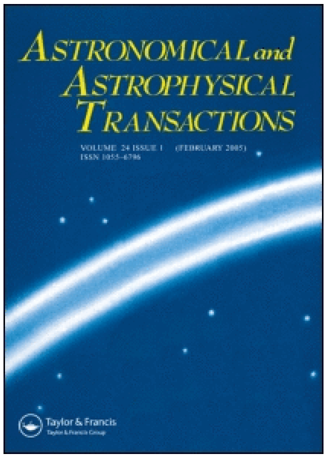

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C_3H_2 $2_{1,2} - 1_{0,1}$ OBSERVATIONS OF SOME MOLECULAR CLOUDS

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The $2_{1,2} - 1_{0,1}$ C_3H_2 line at 85338.90 MHz was firstly detected in a few dark cold clouds and warm clouds associated with H II regions. The integrated line intensity is about the same in the both types of sources. The C_3H_2 column densities are $(0.5 \div 5) \times 10^{13}$ cm^{-2}. In some cases the size of the emitting regions was estimated. It ranges from $\sim 1.'5$ to $< 3.'8$.

KEY WORDS Interstellar medium, clouds, individual – Interstellar medium; molecules – Radio lines, molecular

1 INTRODUCTION

The aim of this work was to survey a sample of dense molecular clouds, studied earlier in various molecular lines, in the $2_{1,2} - 1_{0,1}$ C_3H_2 line using a very low noise maser receiver (Shul'ga *et al.*, 1991). In particular, we tried to detect this line in some warm molecular clouds associated with H II regions where only upper limits have been reported earlier. A few dark clouds have been observed in order to collect the data for their modelling and to study the variations of the C_3H_2 abundance.

Several clouds from our list have been observed earlier in other C_3H_2 lines. In principle, this enables the determination of the cloud density and other physical parameters and we present here these estimates performed in the LVG approximation. However the beam sizes in these observations differ significantly from our one and the source sizes are unknown, so this determination is very uncertain and should be improved by additional observations in various lines.

A few clouds have been observed in the same line with the other instruments. From the comparison of our results with these data, we estimated the source sizes.

2 OBSERVATIONS

The observations were carried out during one night in August 1991 using the 22-m radio telescope of the Crimean Astrophysical Observatory equipped with the 3 mm maser receiver (Shul'ga *et al.*, 1991). The receiver noise temperature was $\sim$ 60 K. The backend was 120×100 kHz filter bank. At the frequency of the $2_{1,2} - 1_{0,1}$ C_3H_2 line (85338.90 MHz) it provides 0.35 km/s velocity resolution. The HPBW at this frequency is 40″. The antenna pointing was checked by observations of planets and SiO maser sources. The r.m.s. pointing errors are $\sim$ 15″ in azimuth and elevation.

The observations were conducted in the beam switching mode (ON–ON). The beam separation was $\sim$ 7′. The typical total integration time was $\sim$ 25 min.

The calibration was performed by the usual chopper-wheel technique (Penzias and Burrus, 1973; Ulich and Haas, 1976). The measurement results are expressed in the units of the radiation temperature T_R^*, corrected for atmospheric, Ohmic and spillover losses (Kutner and Ulich, 1981). The beam efficiency was estimated from the comparison of our data at nearby frequencies (HCN and SiO lines) with the corresponding results obtained with the 20-m radio telescope in Onsala.

Table 1 Source positions and the C_3H_2 line parameters in the observed sources. The values of T_R^*, V_{LSR} and ΔV are the results of one-component Gaussian fit. The figures in the parenthesis are the uncertainties (in the last digits).

Source	$\alpha(1950)$ h m s	$\delta(1950)$ ° ′ ″	T_R^* K	V_{LSR} km/s	ΔV km/s
L673	19 18 33.0	11 07 30	<0.27		
L810	19 43 21.9	27 43 40	0.26(09)	15.7(4)	2.41(81)
L1262	23 23 32.2	74 01 45	0.82(12)	4.2(1)	0.80(11)
L1489	04 01 45.0	26 10 33	1.82(28)	7.3(1)	0.72(22)
L1551	04 28 40.2	18 01 42	1.54(14)	7.1(1)	1.09(09)
S140	22 17 53.3	63 03 40	0.52(07)	−7.4(1)	2.01(24)
S158	23 11 36.5	61 11 51	0.27(06)	−56.2(6)	5.7(1.2)
S252G	06 04 48.0	20 40 00	<0.29		
S273	06 38 24.9	09 32 29	0.71(10)	8.6(1)	2.19(28)
G35.2-0.74	18 55 41.0	01 36 30	0.45(07)	32.6(2)	2.34(34)

3 RESULTS

Our sample included 5 dark clouds, 4 clouds associated with Sharpless H II regions and the molecular cloud G35.2–0.74 (the northern part of it) which represents a region of active star formation. The source list and the measured line parameters are collected in Table 1. The presented values of T_R^*, V_{LSR} and ΔV are the results of one-component Gaussian profile fits to the observational data. The upper limits equal to 2σ where σ is the r.m.s. noise in channels. The measured spectra are presented in Figure 1.

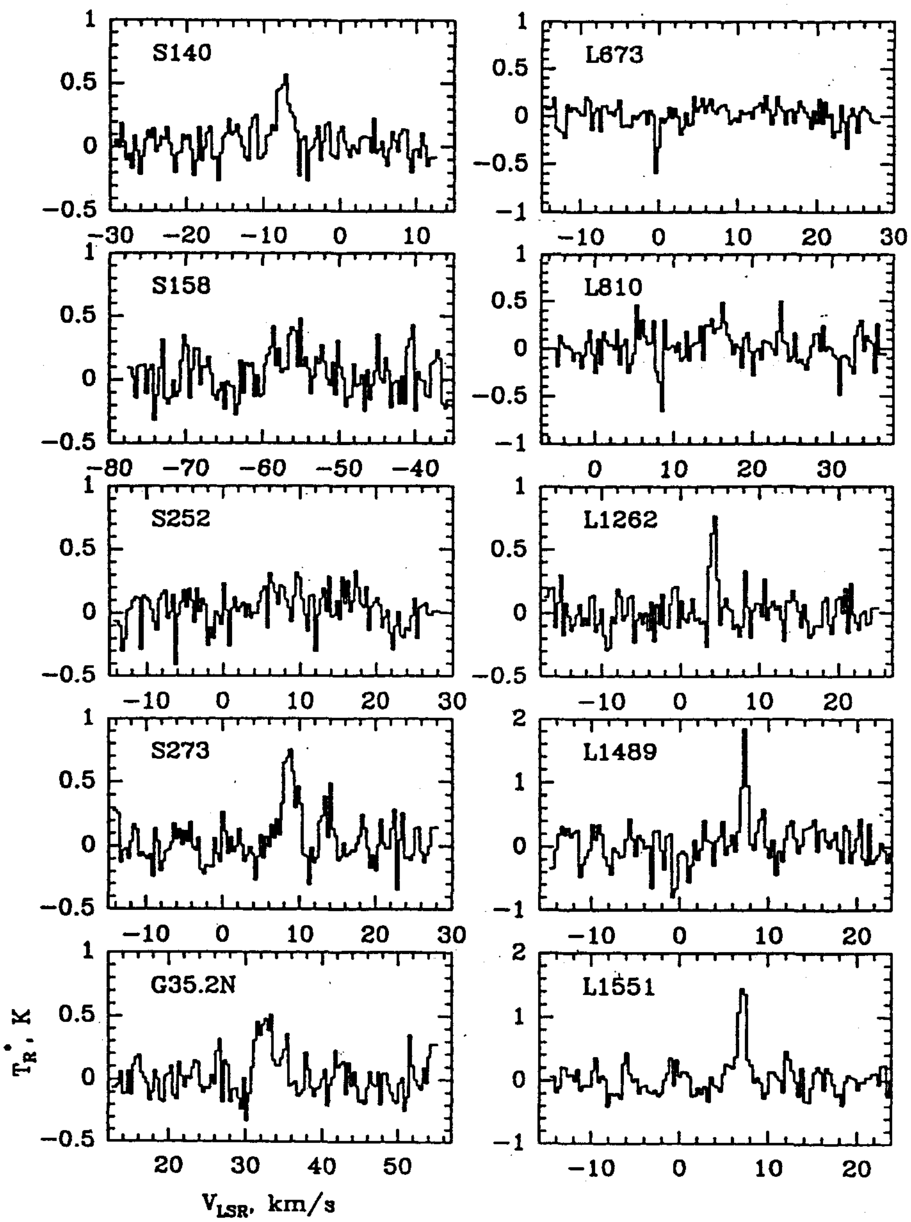

Figure 1 The measured C_3H_2 spectra in the sample sources.

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In two clouds, S273 and G35.2–0.74, second velocity components are probably seen. We present in Table 2 the results of two-Gaussian fitting for them. These second components are not very reliable especially in G35.2–0.74 where the signal-to-noise ratio is only ~ 3. However, it is located at the velocity corresponding to the emission peak in many other molecular lines, so we consider it to be real.

Table 2 The results of two-Gaussian fitting for S273 and G35.2–0.74 (N)

Source		T_R^* K	V_{LSR} km/s	ΔV km/s
S273	(1)	0.71(08)	8.6(1)	2.13(11)
	(2)	0.35(09)	13.6(1)	1.55(18)
G35.2-0.74N	(1)	0.54(07)	32.5(1)	2.28(14)
	(2)	0.35(12)	35.2(1)	0.82(13)

Some sources from this sample have been observed in this line earlier by other groups. Cox *et al.* (1989) detected a strong C_3H_2 emission in L1489 with the 30-m IRAM radio telescope. Brouillet *et al.* (1988) reported the detection of this line in L1551 and upper limits for S140 and S158 obtained with the 2.5-m radio telescope in Bordeaux.

4 DISCUSSION

The C_3H_2 molecule is appropriate for studying dense regions in molecular clouds. It has large dipole moment (3.27 D; Lovas *et al.*, 1992) and many observable rotational transitions which are close in frequency but differ significantly in energy above the ground state. Calculations show that the intensity ratios of some transitions are good indicators of density (Cox *et al.*, 1989). Besides, the C_3H_2 rotational temperature can be determined from observations of several transitions.

Our data are restricted to one line only and do not enable the determination of the temperature or density. We can estimate the beam averaged C_3H_2 column density for the LTE conditions and optically thin case. Assuming the exitation temperature equal to 10 K, we obtain, from the line area, $N_L(C_3H_2)$ to range from $\sim 2 \times 10^{13}$ cm^{-2} to $\sim 5 \times 10^{13}$ cm^{-2} (Table 3).

Several clouds from our list have been observed earlier in other C_3H_2 lines. In particular, Cox *et al.* (1989) observed the 18.3 GHz and 21.6 GHz lines in L1489 with the 100-m Effelsberg antenna. The beam size in these observations was 54″ and 42″, respectively. Madden *et al.* (1989) observed L1551, L1262, S140, S158 and S273 in the 18.3 GHz (HPBW = 99″) and 21.6 GHz (HPBW = 77″) lines with the 42.7-m NRAO radio telescope. We used these data for the determination of the cloud density and the C_3H_2 column density on the base of the LVG modeling. For the other clouds, only lower limits on the C_3H_2 column density were determined using the same LVG approach. For these estimates, we used the collisional rates

Table 3 The derived source parameters

Source	T_{kin} K	N_L^{LVG} 10^{13} cm^{-2}	$lg\, n(H_2)$ cm^{-3}	N_L^{LTE} 10^{13} cm^{-2}
L810	20^a	>0.2		5.0
L1262	20^a	0.6	5.3	1.9
L1489	20^a	2.3	4.4	3.8
L1551	20^a	>0.8		4.9
S140	30^a	>0.4		3.0
S158	20^a	1.1	4.7	2.0
S273	20^a	>0.6		4.5
G35.2-0.74	30^a	>0.4		3.1

[a] assumed

calculated by Avery and Green (1989) multiplied by a factor of 1.5 to account for the difference in molecular weights of the collision partners. The ortho- to para-C_3H_2 ratio was assumed to be 3/1 according to the statistical weights.

The results of the LVG modeling are presented in Table 3 too. The assumed kinetic temperatures for each source are also indicated. We were unable to find the LVG solution for the available data on L1551 and S273. In the first case, the T_R^*(85.3 GHz)/T_R^* (18.3 GHz) ratio is higher than the model allows. In the second case, the situation is opposite. Perhaps it is due to the difference in the beam sizes and measurement errors. The calibration uncertainties should be also taken into account. We mention only that higher values of this ratio correspond to higher densities.

As can be seen from Table 3, the LTE and LVG estimates of $N_L(C_3H_2)$ are in a reasonable agreement. It should be noted that the column densities are about the same in the detected dark cold clouds and warm clouds associated with H II regions. Earlier, C_3H_2 has been detected mainly in dark clouds. Our data show that it is easily detectable in warm clouds too. This does not mean that the relative abundance of C_3H_2 is the same in the both types of clouds. Probably, it is lower in warm clouds because they are known to be denser and larger than cold clouds on the average.

We can estimate the size of C_3H_2 emitting regions in some clouds from the comparison of our data with the previous results. Brouillet *et al.* (1988) observed some of these clouds using the 2.5-m telescope with a 5.′8 beam. Then we obtain that the emitting region size is ~ 1.′5 in L1489, 2′ ÷ 2.′5 in L1551 and < 3.′8 in S140. Now we wish to make additional comments on some individual sources.

The measured integrated line intensity in L1489 ($T_R^* \cdot \Delta V = 1.3$ K km/s) is about the same as obtained by Cox *et al.* (1989) with the IRAM radio telescope (1.15 K km/s). They measured a lower line width due to a better spectral resolution.

The C_3H_2 detection in L810 is marginal. However, the detected line in any case is too broad for a dark cloud and resembles those lines in warm clouds. The

HCN J $= 1 - 0$ line parameters also are typical of a warm cloud (Harju, 1989). So it should be probably classified as a warm cloud. The kinetic temperature in its interior is 14–20 K from ammonia observations (Neckel *et al.*, 1985). There is the IR point source IRAS 19433+2743 in the centre with the luminosity corresponding to the spectral type B3 or later at the distance of 2.5 kpc (Turner, 1986).

The absence of detectable C_3H_2 emission in L673 is rather puzzling because its physical properties are typical of dense, cold clouds (Zinchenko and Kislyakov, 1985; Sandell *et al.*, 1985). The J $= 1 - 0$ HCN line emission is stronger in this source than in L1262 for example (Sandell *et al.*, 1985; Harju, 1989). Probably the lack of the C_3H_2 emission is due to some chemical effects which should be further investigated.

S252 is a complex molecular cloud with a strong emission in various molecular lines (e.g., Haikala, 1986). The component designated here as G is a cold clump in the north-western part of it (Lada and Wooden, 1979).

In S273 and G35.2–0.74N, the C_3H_2 line probably shows a double structure. Both sources are known to have a complex spatial and velocity structure, so in the C_3H_2 line different clumps are probably detected in each case.

5 CONCLUSIONS

Observations with a low-noise maser receiver have shown that C_3H_2 is equally detectable in both cold dark clouds and warm clouds associated with H II regions. The integrated line intensities are about the same and correspond to the C_3H_2 column densities $(0.5 \div 5) \times 10^{13}$ cm^{-2}. The size of the emitting regions ranges from $\sim 1.'5$ to $< 3.'8$ (in a few sources where such an estimate is possible from comparison with observations with lower angular resolution).

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