Studies of dense molecular cores in regions of massive star formation.

IV. Multitransition CS-study towards southern H₂O masers in the longitude range $l=308^\circ-360^\circ$,**

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Abstract. — We have observed CS and C³⁴S emission towards 33 H₂O maser positions in the southern sky ($\delta < -28^\circ$) using the SEST telescope. Most of the sources were selected also for their association with strong IRAS sources. CS(2–1) was detected in all sources, with the possible exception of two. Most sources were also mapped in the transitions CS(5–4) and C³⁴S(2–1) and half of the sample also in CS(2–1). CS and C³⁴S transitions $J = 2-1$, $J = 3-2$, $J = 5-4$ were measured towards the centres of the clouds as determined from the mapping. CS and C³⁴S transitions $J = 7-6$ were measured in about a half dozen clouds. CO(1–0) was measured in most clouds in order to determine the kinetic temperatures. The CS column densities were calculated using the LTE approximation. All measurements were also analyzed using a spherical LVG model. We present the observational data and the results of this analysis.

Key words: masers — stars: formation — ISM: clouds — ISM: molecules — radio lines: ISM

1. Introduction

Several massive star forming regions have already been subject to detailed investigations (see e.g. reviews by Genzel 1991; Churchwell 1991) but until recently there have not been any systematic studies based on a larger number of such cloud cores. Since the previous studies have concentrated on a few of the most prominent sites, generalization of the results obtained by these investigations to the whole class of massive star forming cores is still uncertain.

Zinchenko et al. (1995) have recently published observations of CS(2–1) and C³⁴S(2–1) in 30 southern cores associated with H₂O and OH maser emission. The present paper represents a continuation of this study.

Like Zinchenko et al. we have selected the sources mainly from the list of nonstellar maser sources published by Braz & Epchtein (1983). H₂O maser emission has been detected towards almost all of them; in one case only OH maser emission has been detected. H₂O masers are known to be good indicators of the location of massive star

formation and the list of Braz and Epchtein presents a rather comprehensive and unbiased selection of such sources. Our objective is to present a sample large enough to facilitate general conclusions about regions of massive star formation.

In this paper we present the results of observations towards 33 new southern cloud cores. CS molecule was chosen because it is an excellent density probe and also the isotope C³⁴S can be easily detected. Furthermore, CS has several suitable millimeter and submillimeter transitions that enable multitransition modelling of the clouds. We have observed several CS and C³⁴S transitions in all cores and the measurements enable us to derive the basic physical parameters of the cores, both in LTE approximation and through LVG modeling.

Some of the objects are already well known and have been observed in the past using different molecules e.g. CO and NH₃. The presence of such measurements also gives the opportunity to make some comparisons between the results obtained using different molecular probes.

*Based on the observations collected at the European Southern Observatory, La Silla, Chile

**Tables 2, 3 and 5–7 are also available in electronic form at the CDS via anonymous ftp 130.79.128.5

2. Observations and data analysis

2.1. Observational procedure

The observations were made using the 15-meter SEST telescope on La Silla, Chile. Our sample consists of 33 dense cloud cores. Practically all clouds were mapped at least in C³⁴S(2–1) and CS(5–4) and many additional smaller maps were made using the transitions CS(2–1) and CS(3–2). The maps were used to determine the centre positions of the cloud i.e. the position of the maximum emission. The transitions $J = 2 - 1$, $3 - 2$ and $5 - 4$ of both CS and C³⁴S were then observed at these centre positions in almost all of the clouds. Additional onepoint measurements of the transition CS(7–6) were made in 14 clouds and of the transition C³⁴S(7–6) in seven clouds.

Observations were made during three different periods. The CS(2–1) maps and some of the CS(5–4) maps were made in April 1994. In February 1995 we mapped the clouds in C³⁴S(2–1) and CS(5–4) and observed the $J = 2 - 1$ and $J = 5 - 4$ transitions towards the centre positions. CO(1–0) was also observed towards most of the centre positions. The CS and C³⁴S transitions $J = 3 - 2$ and $J = 7 - 6$ were observed in June 1995 with some additional C³⁴S(2–1) observations.

The telescope and the 1.3 mm and the 3 mm receivers are described by Booth et al. (1989). Table 1 lists the observed transitions and the beam sizes at these frequencies.

Table 1. The observed transitions. The third column gives the critical density at which the collisional and the spontaneous radiative transition rates are equal and the last column the beam size of the SEST radiotelescope at these frequencies

Transition	frequency (GHz)	n_c (cm ⁻³)	beam size (")
C ³⁴ S(2–1)	96.4130	$5.4 \cdot 10^5$	52
CS(2–1)	97.9810	$5.7 \cdot 10^5$	52
C ³⁴ S(3–2)	144.6171	$1.4 \cdot 10^6$	36
CS(3–2)	146.9690	$1.5 \cdot 10^6$	35
C ³⁴ S(5–4)	241.0161	$6.9 \cdot 10^6$	22
CS(5–4)	244.9357	$7.2 \cdot 10^6$	22
C ³⁴ S(7–6)	337.397	$2.1 \cdot 10^7$	16
CS(7–6)	342.8829	$2.2 \cdot 10^7$	15

For the $J = 2 - 1$ observations the front end was a 3 mm Schottky mixer receiver. The single sideband system temperatures outside the atmosphere were typically 350–450 K for both CS and C³⁴S. For the $J = 3 - 2$ observations the system temperatures of the SIS receiver were around 200 K. A 1.3 mm SIS receiver was used for $J = 5 - 4$ observations. The system temperatures varied between 600 and 1000 K during both observation periods in 1994 and in 1995. The $J = 7 - 6$ observations were made using a 0.8 mm SIS receiver (Whyborn et al. 1992). Because of the unfavorable weather conditions in June 1995 the system temperatures were around 1000 K during the

CS(7–6) observations and between 1000 and 1500 K during the C³⁴S(7–6) observations.

The backend was a 2000 channel acousto-optical spectrometer with a 100 MHz bandwidth, a channel separation of 43 kHz and a resolution of 80 kHz.

The maps were made mainly in the frequency switching mode. The maps consist typically of around 30 points and cover at least the area where the intensity of the C³⁴S(2–1) line is more than half of the peak value. All centre point measurements and some maps were made using beam switching with a beam throw of 11'37" or with position switching.

Pointing was checked every three or four hours by observing nearby SiO masers. The pointing accuracy is expected to be approximately 5". On some occasions the observations were hampered by strong winds. Therefore, in some cases, the pointing may not have been this accurate.

The calibration was made using the chopper-wheel technique. We present the observational results in the main beam brightness temperature scale. These temperatures were obtained by dividing the observed antenna temperatures T_A^* with the main beam efficiency η_{mb} as given in the SEST Handbook (1993). This procedure gives in Orion SiO ($\alpha = 5^h32^m47.0^s$, $\delta = -5^\circ24'23''$) a peak main beam temperature of 15.1 K at CS(2–1) and for M17SW temperatures 1.9 K, 18.0 K and 8.20 K for C³⁴S(2–1), CS(3–2) and CS(5–4), respectively. An additional elevation dependent correction had to be made to those $J = 7 - 6$ observations where the elevation was below 60° (Nyman 1995, private communication). This correction is somewhat uncertain but since practically all observations were made above this limit this correction should have little effect on the results we present here. The main beam temperature for M17SW CS(7–6) was, after corrections, 14.1 K.

2.2. Source list

The source list in Table 2 is mainly a subset of the catalogue of Braz & Epchtein (1983) of non-stellar molecular maser sources. One additional source (G 021–0.01) was taken from the article by Güsten & Downes (1983), two sources (G 318.05+0.09 and G 323.74–0.25) are from an article by Scalise et al. (1989) and two sources (G 308.00–0.25 and G 316.37–0.37) from Braz et al. (1989). The clouds are situated southwards of $\delta = -28^\circ$ and extend over the galactic longitude range from 308° to about 360°. Table 2 gives details of the sources. The name in the first column refers to the position of the H₂O maser and the following coordinates are for the zero offset positions in the cloud maps (mostly the positions of maximum C³⁴S(2–1) emission). The following column contains the radial velocity of the H₂O maser. The next three columns list the galacto-centric distance, distance from the Sun as determined from the observed CS velocity, and the height

Table 2. The source list. The radial velocity of the H₂O maser is given in Col. (8) and the galacto-centric distance is in Col. (9). Columns (10) and (11) contain the kinematic distance and the height above the galactic plane. Some distance estimates from the literature are given in Col. (12)

Name	RA (1950)			Dec (1950)			$V_{\text{H}_2\text{O}}$ km/s	R_G (kpc)	d (kpc)	z (pc)	d_{ref} (kpc)	Maser references
(1)	(h)	(m)	(s)	(°)	(')	(")	(8)	(9)	(10)	(11)	(12)	(13)
G 308.00-0.25	13	29	27.0	-60	11	22	-22	7.41	2.06/(8.41)	72/296		c
G 308.92+0.12, RCW 79	13	39	34.4	-61	53	45	-51	6.47	—	—	4.0 ²	b
G 309.92+0.48	13	47	12.5	-61	20	38	-58	6.24	—	—	4.0 ⁴	g
G 311.94+0.18	14	4	3.0	-61	7	6	-42	—	—	—		b
G 316.37-0.37	14	39	26.3	-60	4	33	-3	8.30	(0.28)/12.03	(-2)/-76	14.7 ¹	c
G 316.64-0.08	14	40	30.0	-59	42	18	(-19) [†]	7.43	(1.58/10.78)	(-2/-15)		
G 316.77-0.02	14	41	10.4	-59	35	50	-41	6.58	3.12/(9.26)	-1/(-3)	2.5 ¹	a, g
G 316.81-0.06	14	41	41.7	-59	36	53	-39	6.66	2.95/(9.45)	-3/(-10)	2.5 ³	a, g
G 318.05+0.09	14	49	51.9	-58	56	40	-51	6.25	3.73/(8.92)	6/(13)		j
G 323.74-0.25	15	27	54.6	-56	20	55	-50	6.04	3.50/(10.20)	-16/(-47)	3.0 ⁹	j
G 324.20+0.12	15	29	1.2	-55	46	12	-88	4.95	—	—	6.9 ⁶	a
G 328.30+0.43	15	50	15.3	-53	2	46	-93	4.64	(5.97)/8.49	44/(63)	8.5 ¹	a
G 329.04-0.21	15	56	39.3	-53	4	10	-44	6.03	3.14/(11.43)	-11/(-40)		j
G 331.00-0.19	16	6	3.4	-51	47	30	-92	4.49	5.65/(9.21)	-18/(-30)	6.4 ³	a
G 330.88-0.36	16	6	30.0	-51	58	14	-63	5.24	4.20/(10.65)	-27/(-69)	4.1 ¹	a, g
G 331.28-0.18	16	7	36.0	-51	33	40	-88	4.54	5.47/(9.44)	-18/(-31)		b
G 332.65-0.63, RCW 106	16	15	55.7	-50	56	48	-50	5.55	3.60/(11.50)	-38/(-123)	3.6 ¹	a, g
G 332.83-0.55, RCW 106	16	16	23.7	-50	45	45.5	-57	5.29	3.97/(11.15)	-38/(-107)	4.2 ³	b
G 333.13-0.43	16	17	16.8	-50	28	17	-52	5.44	3.73/(11.44)	-28/(-87)	3.8 ¹	a
G 333.60-0.22	16	18	22.4	-49	59	27	-48	5.54	3.56/(11.66)	-14/(-45)	3.5 ¹	a
G 337.40-0.40	16	35	8.1	-47	22	23	-41	5.55	3.36/(12.34)	-24/(-87)		a
G 337.91-0.47	16	37	25.9	-47	2	6	-39	5.57	3.31/(12.44)	-28/(-104)	3.4 ¹	a, i
G 345.01+1.80, RCW 116	16	53	17.3	-40	9	23.2	-14	6.45	2.14/(14.28)	67/(447)	3.0 ⁷	d, e
G 343.12-0.06	16	54	44.0	-42	47	36.6	-31	5.51	3.20/(13.07)	-4/(-15)		a, e
G 345.51+0.35	17	0	53.6	-40	40	18.5	-17	6.11	2.50/(13.96)	15/(85)	2.1 ⁷	a, e, g, i
G 345.00-0.23	17	1	40.1	-41	24	58.5	-27	5.49	3.18/(13.24)	-12/(-52)	3.2 ⁷	d, e
G 345.41-0.94, RCW 117	17	6	2.2	-41	32	6.3	-22	5.81	2.82/(13.63)	-47/(-225)	2.8 ¹	a, e
G 348.55-0.97	17	15	53.1	-39	0	57	-15	5.78	2.80/(13.86)	-48/(-237)	2.1 ¹	d, e
G 351.16+0.70, RCW 127, NGC 6334B	17	16	36.1	-35	54	51	-6	6.45	2.08/(14.72)	25/(180)		a, e, h
G 348.73-1.04, RCW 122	17	16	39.8	-38	54	13.6	-12	6.14	2.43/(14.25)	-44/(-259)	2.1 ¹	a, e, g, i
G 351.41+0.64, NGC 6334I	17	17	32.3	-35	44	2.5	-7	6.40	(2.13/14.68)	24/(165)	1.7 ⁵	a, e, h
G 0.21-0.01	17	42	57.0	-28	44	5	25	-	7.36/(9.64)	0/(0)		f
G 359.97-0.46	17	44	9.2	-29	10	57.7	18	-	8.43/(8.57)	-67/(-68)		d, e

Distance references: ¹Caswell & Haynes (1987), ²Henning et al. (1990), ³Lockman (1979), ⁴Moorwood et al. (1983), ⁵Neckel et al. (1978) ⁶Simpson et al. (1990), ⁷Testi et al. (1994), ⁸Zavagno et al. (1992).

Maser references: a) Batchelor et al. (1980), b) Braz & Scalise (1982), c) Braz et al. (1989), d) Caswell et al. (1983), e) Forster & Caswell (1989), f) Güsten & Downes (1983), g) Kaufmann et al. (1977), h) Moran & Rodriguez (1980), i) Scalise & Braz (1980), j) Scalise et al. (1989).

[†] Velocity of an OH maser.

Table 3. CS and C³⁴S line areas and Gaussian line parameters for the central positions of the sources. Under the name are the offsets of the observed position relative to the positions given in Table 2. The numbers enclosed in brackets indicate the statistical uncertainties in the last digits as given by the fitting procedure for the Gaussian line parameters or as deduced from the baseline noise level in case of the integrated line temperature. Columns (7), (12) and (13) indicate some features of the spectra: blue and red wings are marked with b and r and strong absorption features with an a

Source	J	C ³⁴ S					CS					CO
		$\int T_{mb} dv$ (K km/s)	T_{mb} (K)	V_{LSR} (km/s)	ΔV (km/s)	wing	$\int T_{mb} dv$ (K km/s)	T_{mb} (K)	V_{LSR} (km/s)	ΔV (km/s)	wing	wing
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
G308.00-0.25 (0,0)	2	2.38(0.13)	0.58(0.18)	-22.83(0.36)	3.88(0.91)		20.41(0.20)	3.93(0.07)	-22.72(0.03)	4.81(0.07)		
	3	2.18(0.06)	0.70(0.03)	-22.35(0.04)	2.92(0.10)		20.61(0.19)	3.88(0.03)	-22.31(0.01)	4.92(0.03)	br	
	5	1.80(0.89)	0.22(0.15)	-23.58(2.20)	8.44(4.33)		19.83(0.68)	3.90(0.18)	-22.22(0.06)	4.45(0.17)		
	7	- (-)	- (-)	- (-)	- (-)		7.19(1.01)	1.94(0.24)	-22.16(0.16)	3.41(0.32)		
G308.92+0.12 (0,0)	2	2.75(0.16)	0.98(0.07)	-51.03(0.07)	2.82(0.14)		20.26(0.25)	4.79(0.08)	-50.85(0.02)	3.83(0.05)		b
	3	5.11(0.06)	1.42(0.03)	-50.84(0.02)	3.37(0.05)		25.04(0.15)	5.81(0.03)	-50.77(0.01)	4.00(0.02)	b	
	5	3.33(0.31)	0.98(0.13)	-51.27(0.11)	2.95(0.32)		22.39(0.58)	5.17(0.19)	-50.78(0.04)	3.91(0.12)		
	7	2.04(2.51)	3.17(1.07)	-48.52(0.13)	0.68(0.15)		31.68(0.96)	7.43(0.21)	-50.92(0.04)	4.00(0.09)		
G309.92+0.48 (0,0)	2	3.26(0.14)	0.91(0.07)	-58.43(0.08)	3.14(0.19)		15.26(0.19)	3.30(0.08)	-58.44(0.03)	4.30(0.08)	b	br
	3	3.94(0.08)	1.04(0.03)	-58.17(0.03)	3.32(0.09)		18.29(0.25)	3.77(0.03)	-58.45(0.01)	4.49(0.03)	br	
	5	0.49(0.29)	0.93(0.20)	-58.30(0.06)	0.69(0.10)		7.70(0.64)	2.14(0.20)	-58.70(0.09)	3.15(0.22)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G311.94+0.18 (0,0)	2	0.69(0.19)	0.18(0.06)	-36.93(0.54)	3.28(0.66)		1.83(0.18)	0.56(0.17)	-42.18(0.26)	3.12(0.74)		
	3	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
	5	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G316.37-0.37 (0,0)	2	1.27(0.14)	0.12(0.05)	-0.57(1.16)	9.95(3.22)		3.79(0.13)	0.71(0.05)	-1.55(0.14)	5.26(0.28)		
	3	0.27(0.09)	0.09(0.02)	-1.88(0.52)	4.40(0.80)		- (-)	- (-)	- (-)	- (-)		
	5	1.46(0.28)	0.57(0.19)	0.01(0.15)	1.47(0.38)		-0.49(0.50)	0.32(0.20)	-2.60(0.35)	1.21(0.57)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G316.64-0.08 (-20,0)	2	0.02(0.07)	0.29(0.16)	-18.73(0.17)	0.92(0.40)		0.34(0.17)	0.52(0.05)	-18.32(0.17)	4.88(0.37)		
	3	-0.05(0.03)	0.19(0.06)	0.24(0.05)	0.37(0.08)		0.16(0.08)	0.52(0.03)	-18.03(0.08)	4.53(0.19)		
	5	-0.58(0.22)	0.95(0.41)	-20.76(0.05)	0.38(0.13)		-0.22(0.32)	0.43(0.11)	-20.32(0.31)	4.30(0.87)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G316.77-0.02 (20,20)	2	2.15(0.12)	0.42(0.07)	-40.84(0.23)	4.60(0.58)		15.96(0.18)	2.51(0.06)	-39.74(0.04)	5.87(0.10)		b
	3	0.61(0.06)	0.15(0.03)	-39.64(0.22)	3.95(0.51)		13.14(0.15)	2.30(0.03)	-39.93(0.02)	5.18(0.05)	b	
	5	0.11(0.23)	0.79(0.42)	-40.44(0.05)	0.38(0.16)		6.12(0.40)	0.85(0.09)	-39.62(0.21)	6.87(0.54)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G316.81-0.06 (0,20)	2	2.83(0.11)	0.73(0.07)	-38.47(0.10)	3.35(0.25)		18.96(0.23)	3.91(0.07)	-38.51(0.02)	4.55(0.06)		b
	3	2.39(0.07)	0.69(0.03)	-37.98(0.04)	3.14(0.11)		22.69(0.15)	4.82(0.03)	-38.24(0.01)	4.48(0.02)		
	5	1.80(0.40)	0.46(0.09)	-37.55(0.27)	3.83(0.58)		12.32(0.40)	2.98(0.10)	-38.08(0.04)	3.87(0.10)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G318.05+0.09 (20,0)	2	3.21(0.15)	0.98(0.09)	-49.91(0.08)	2.87(0.21)		22.76(0.38)	5.04(0.08)	-50.12(0.02)	4.11(0.05)		r
	3	3.92(0.08)	1.18(0.03)	-49.94(0.02)	3.02(0.06)		26.68(0.40)	5.64(0.04)	-50.17(0.01)	4.35(0.02)		
	5	2.78(0.39)	1.13(0.14)	-49.58(0.09)	2.20(0.21)		20.47(0.42)	4.45(0.12)	-50.07(0.03)	4.20(0.09)		
	7	- (-)	- (-)	- (-)	- (-)		17.07(0.80)	4.24(0.21)	-50.21(0.06)	3.78(0.14)		
G323.74-0.25 (0,20)	2	2.23(0.14)	0.55(0.06)	-49.57(0.16)	4.17(0.32)		12.42(0.23)	2.48(0.07)	-49.15(0.04)	4.51(0.09)		
	3	1.98(0.08)	0.46(0.04)	-49.56(0.06)	3.39(0.22)		13.25(0.20)	2.40(0.04)	-49.05(0.02)	5.10(0.06)	b	
	5	-0.04(0.19)	1.93(0.69)	-51.73(0.02)	0.16(0.04)		7.69(0.41)	1.50(0.12)	-49.50(0.11)	4.67(0.32)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G324.20+0.12 (0,30)	2	4.45(0.11)	0.87(0.06)	-88.70(0.10)	4.71(0.25)		24.79(0.30)	3.98(0.07)	-88.41(0.03)	6.03(0.08)		r
	3	5.33(0.11)	1.04(0.03)	-88.48(0.04)	4.57(0.11)	b	32.95(0.40)	4.66(0.03)	-88.26(0.01)	7.43(0.04)	br	
	5	5.11(0.41)	1.00(0.14)	-88.45(0.16)	4.38(0.51)		25.98(0.53)	3.74(0.09)	-87.93(0.05)	7.24(0.15)	b	
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		

above the galactic plane. The near and far kinematic distances were calculated by assuming a flat rotation curve for the Galaxy (Fich et al. 1989). For some sources the Col. (12) gives a distance estimate obtained from the literature. These distances, d_{ref} , are either more accurate than the calculated kinematic distances or represent the preferred kinematic distance used in some previous article. In cases where the kinematic distances had to be used we have adopted the one in Col. (10) which is not enclosed in parenthesis. For many sources the selection of the distance is based on the distance estimates of Lockman

(1979) and/or Caswell & Haynes (1987). The kinematic distances are uncertain especially close to the galactic centre but even the estimates for the clouds G 0.21–0.01 and G 359.97–0.46 are still reasonable.

The first seven objects in Table 2 were taken from the initial selection of maser sources in the order of increasing right ascension. No selection criteria were applied to them. In one of these sources, G 316.64–0.08, no H₂O maser emission has been detected to our knowledge and the source is associated with an OH maser only. The maser

Table 3. continued

Source	J	C ³⁴ S					CS					CO
		$\int T_{mb} dv$ (K km/s)	T_{mb} (K)	V_{LSR} (km/s)	ΔV (km/s)	wing	$\int T_{mb} dv$ (K km/s)	T_{mb} (K)	V_{LSR} (km/s)	ΔV (km/s)	wing	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
G328.30+0.43 (20,-20)	2	4.87(0.10)	0.77(0.05)	-92.60(0.12)	6.02(0.27)		32.83(0.46)	4.93(0.06)	-92.60(0.02)	6.21(0.06)	r	a
	3	5.41(0.09)	0.93(0.02)	-92.45(0.04)	5.54(0.10)		36.70(0.40)	5.59(0.03)	-92.60(0.01)	6.17(0.03)	r	
	5	2.77(0.34)	0.46(0.13)	-91.59(0.41)	5.77(1.37)		30.45(0.47)	4.67(0.10)	-92.60(0.04)	6.10(0.10)		
	7	- (-)	- (-)	- (-)	- (-)		23.78(0.85)	4.00(0.13)	-92.37(0.07)	5.63(0.16)		
G329.04-0.21 (20,0)	2	2.83(0.11)	0.55(0.06)	-42.90(0.12)	3.74(0.34)		19.71(0.24)	1.61(0.04)	-44.41(0.10)	14.02(0.26)		b
	3	3.09(0.07)	0.48(0.02)	-43.27(0.07)	5.70(0.21)		22.05(0.20)	1.92(0.02)	-44.06(0.04)	12.36(0.10)		
	5	2.38(0.35)	0.34(0.07)	-43.21(0.49)	7.26(1.12)		15.78(0.37)	2.03(0.08)	-43.41(0.09)	7.32(0.23)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G331.00-0.19 (20,20)	2	12.33(0.16)	1.67(0.05)	-91.55(0.06)	6.98(0.15)		58.05(0.39)	6.75(0.05)	-92.11(0.02)	8.29(0.04)		
	3	14.70(0.10)	1.80(0.02)	-91.80(0.03)	7.72(0.07)		69.58(0.46)	7.91(0.03)	-92.58(0.01)	8.56(0.02)	r	
	5	7.78(0.40)	0.95(0.07)	-91.27(0.19)	8.08(0.48)		60.23(0.44)	6.56(0.10)	-92.55(0.04)	9.12(0.10)		
	7	5.57(0.59)	1.42(0.87)	-87.87(0.08)	0.35(0.18)		43.91(0.98)	4.94(0.13)	-92.50(0.07)	8.92(0.18)		
G330.88-0.36 (20,-20)	2	10.18(0.13)	1.81(0.05)	-62.80(0.04)	4.99(0.11)		46.06(0.35)	6.78(0.06)	-63.11(0.02)	6.25(0.04)	br	br
	3	11.31(0.12)	2.10(0.04)	-62.66(0.03)	4.77(0.08)	b	49.13(0.30)	6.91(0.03)	-62.92(0.01)	6.60(0.02)	b	
	5	2.85(0.35)	0.92(0.12)	-62.84(0.10)	2.52(0.24)		42.58(0.52)	6.13(0.10)	-62.78(0.03)	6.39(0.08)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G331.28-0.18 (40,-20)	2	4.40(0.11)	0.75(0.05)	-88.42(0.12)	5.51(0.31)		18.89(0.14)	3.08(0.06)	-88.52(0.03)	5.77(0.08)	r	
	3	3.93(0.10)	0.90(0.03)	-88.69(0.04)	3.88(0.09)		20.15(0.25)	3.11(0.03)	-88.78(0.02)	5.96(0.05)	r	
	5	2.47(0.32)	0.51(0.09)	-87.97(0.25)	3.91(0.54)		10.52(0.37)	2.03(0.10)	-89.24(0.07)	4.57(0.17)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G332.65-0.63 (-40,40)	2	4.45(0.12)	1.02(0.06)	-49.92(0.07)	4.05(0.17)		21.47(0.13)	3.33(0.05)	-49.98(0.03)	6.20(0.07)		
	3	5.61(0.06)	1.32(0.03)	-49.73(0.02)	3.94(0.06)		25.29(0.19)	4.23(0.06)	-49.72(0.02)	5.67(0.06)	b	
	5	2.57(0.47)	0.90(0.08)	-49.90(0.12)	3.38(0.21)		17.91(0.39)	4.11(0.10)	-49.53(0.03)	4.03(0.08)		
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		
G332.83-0.55 (0,-20)	2	15.67(0.15)	2.15(0.04)	-57.29(0.05)	7.02(0.11)		55.63(0.20)	7.01(0.05)	-57.24(0.02)	7.62(0.04)	b	
	3	21.84(0.12)	3.12(0.03)	-56.96(0.02)	6.64(0.05)		67.64(0.20)	8.39(0.05)	-55.93(0.01)	7.82(0.04)		
	5	20.80(0.42)	2.83(0.08)	-56.71(0.06)	6.87(0.15)		81.12(0.61)	9.66(0.08)	-56.07(0.02)	8.28(0.05)		
	7	24.86(0.79)	4.29(0.14)	-57.22(0.06)	5.57(0.14)		99.20(1.08)	12.16(0.13)	-56.87(0.03)	8.06(0.06)		
G333.13-0.43 (0,0)	2	25.34(0.19)	3.83(0.05)	-52.14(0.02)	5.98(0.05)	b	94.69(0.78)	12.21(0.07)	-52.16(0.01)	7.18(0.03)	br	br
	3	26.23(0.14)	4.21(0.03)	-52.12(0.01)	5.75(0.03)		85.14(0.72)	10.95(0.04)	-51.63(0.01)	7.19(0.02)	b	
	5	12.61(0.35)	2.23(0.08)	-51.62(0.06)	5.24(0.15)		78.41(0.53)	9.86(0.10)	-52.20(0.02)	7.48(0.06)		
	7	11.71(0.84)	2.45(0.16)	-52.55(0.11)	5.01(0.24)		57.20(0.99)	7.90(0.14)	-51.99(0.04)	6.80(0.09)		
G345.01+1.80 (20,-20)	2	10.35(0.13)	2.12(0.04)	-13.97(0.03)	4.48(0.07)		67.14(0.44)	10.64(0.06)	-14.10(0.01)	5.89(0.02)		
	3	12.94(0.11)	2.72(0.03)	-13.69(0.01)	4.37(0.03)		68.68(0.72)	10.29(0.04)	-13.49(0.01)	6.19(0.02)	b	
	5	8.87(0.38)	1.91(0.11)	-13.08(0.06)	3.94(0.17)		66.84(0.62)	10.07(0.09)	-13.57(0.02)	6.16(0.04)		
	7	- (-)	- (-)	- (-)	- (-)		53.34(0.81)	9.43(0.17)	-13.40(0.03)	5.12(0.07)		
G343.12-0.06 (0,0)	2	5.01(0.13)	0.76(0.05)	-30.55(0.11)	6.33(0.33)		27.41(0.51)	3.25(0.06)	-31.18(0.04)	8.61(0.13)	r	
	3	7.43(0.10)	1.05(0.02)	-30.61(0.04)	6.76(0.12)		35.38(0.60)	3.76(0.03)	-31.58(0.03)	10.71(0.08)	ab	
	5	5.20(0.32)	0.71(0.07)	-30.09(0.24)	7.12(0.55)		47.37(0.61)	4.87(0.07)	-30.67(0.05)	11.28(0.13)		
	7	- (-)	- (-)	- (-)	- (-)		68.53(0.92)	7.01(0.12)	-30.53(0.06)	11.22(0.15)		
G345.51+0.35 (0,0)	2	6.24(0.13)	1.22(0.05)	-17.48(0.06)	4.58(0.15)		31.81(0.63)	4.95(0.07)	-17.11(0.02)	5.76(0.07)	b	br
	3	8.64(0.11)	1.59(0.03)	-17.20(0.03)	4.77(0.07)	b	39.27(0.72)	6.00(0.13)	-16.39(0.03)	5.93(0.10)	r	
	5	5.54(0.39)	1.34(0.10)	-16.86(0.09)	3.93(0.21)		38.63(0.70)	6.79(0.13)	-16.27(0.02)	4.94(0.07)	b	
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)		

velocity quoted in Col. (8) of the table is that of the OH maser.

The rest of our sample satisfies the following criteria: (1) the H₂O maser intensity is at least 9 Jy, (2) the source is associated with an IRAS source with an intensity greater than 1500 Jy at 100 μ m and, (3) the projected distance between the maser and the infrared source is less than one arc minute. There are altogether some forty sources satisfying these requirements in the given (α , δ) range that were not already observed by Zinchenko et al. (1995). From this list we selected 22 sources which are associated with the brightest IRAS sources (I (100 μ m) > 3500 Jy). The last three sources G 323.74–0.25, G 318.05+0.09 and G 329.04–0.21 have IRAS intensities of 3260, 2210 and 1650 Jy at 100 μ m.

Many of the clouds are associated with several water maser sources. The last column in the table gives the references for the H₂O maser observations that are used in this article.

Many of the sources in Table 2 have already been studied in different molecular lines: (1) the approximate positions of twelve of the clouds in our current sample have been observed in CS(1–0) by Gardner & Whiteoak (1978); (2) there exist also detailed studies of several clouds made in CO(2–1) (see e.g. de Graauw et al. 1981; White & Phillips 1983; Brand et al. 1984); (3) CH₃OH absorption line measurements exist for eight clouds (Peng & Whiteoak 1992) and, (4) H₂CO absorption measurements for seventeen clouds (Whiteoak & Gardner 1974; Gardner & Whiteoak 1984). Three cores from our sample were also

Table 3. continued

Source	J	C ³⁴ S					wing	CS					wing	CO
		$\int T_{mb} dv$ (K km/s)	T_{mb} (K)	V_{LSR} (km/s)	ΔV (km/s)	$\int T_{mb} dv$ (K km/s)		T_{mb} (K)	V_{LSR} (km/s)	ΔV (km/s)				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)		
G333.60-0.22 (20,0)	2	7.91(0.10)	1.26(0.07)	-48.49(0.10)	5.88(0.24)		55.74(0.28)	7.51(0.06)	-48.25(0.02)	6.98(0.05)		br		
	3	9.31(0.08)	1.26(0.04)	-48.44(0.07)	6.95(0.18)		53.28(0.23)	6.85(0.03)	-48.40(0.01)	7.43(0.02)				
	5	6.73(0.30)	0.77(0.07)	-49.44(0.29)	9.00(0.65)		49.58(0.38)	5.82(0.12)	-48.21(0.05)	8.34(0.13)				
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)				
G337.40-0.40 (20,20)	2	11.45(0.14)	2.25(0.05)	-41.02(0.03)	4.72(0.09)		50.58(0.37)	8.32(0.05)	-41.34(0.01)	5.77(0.03)				
	3	15.44(0.09)	2.92(0.02)	-40.96(0.01)	4.88(0.03)		59.88(0.31)	8.94(0.03)	-40.98(0.01)	6.36(0.02)	r			
	5	8.53(0.31)	1.76(0.09)	-40.72(0.07)	4.28(0.16)		47.36(0.51)	6.72(0.09)	-41.27(0.03)	6.69(0.07)				
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)				
G337.91-0.47 (40,-20)	2	11.09(0.14)	2.41(0.06)	-39.52(0.03)	4.10(0.08)		36.49(0.79)	7.93(0.10)	-40.33(0.02)	3.83(0.04)	b			
	3	20.50(0.16)	3.75(0.03)	-39.14(0.01)	4.93(0.03)	b	51.90(0.88)	8.49(0.06)	-39.74(0.01)	5.33(0.03)	br			
	5	12.67(0.34)	2.32(0.09)	-38.64(0.05)	4.81(0.15)		76.11(0.68)	10.19(0.10)	-38.96(0.02)	7.22(0.06)	br			
	7	22.62(1.01)	3.98(0.21)	-39.00(0.08)	5.04(0.20)		68.23(1.09)	9.08(0.16)	-38.73(0.03)	7.23(0.10)				
G345.00-0.23 (0,0)	2	5.26(0.11)	0.60(0.04)	-27.12(0.15)	8.13(0.38)		25.14(0.45)	1.78(0.03)	-25.72(0.08)	15.70(0.19)	a			
	3	8.49(0.09)	0.98(0.02)	-26.77(0.06)	7.99(0.15)		47.15(0.56)	3.65(0.02)	-25.95(0.02)	13.62(0.05)	a			
	5	6.04(0.36)	0.96(0.08)	-27.57(0.15)	5.62(0.37)		48.09(0.59)	5.35(0.07)	-26.21(0.04)	8.44(0.09)	b			
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)				
G345.41-0.94 (0,0)	2	11.32(0.17)	2.82(0.06)	-21.56(0.02)	3.61(0.06)		45.45(0.26)	11.02(0.07)	-21.47(0.01)	3.78(0.02)		r		
	3	16.94(0.16)	4.31(0.04)	-21.33(0.01)	3.58(0.02)		63.12(0.42)	13.61(0.04)	-21.22(0.00)	4.28(0.01)				
	5	12.46(0.38)	3.26(0.13)	-21.34(0.04)	3.37(0.11)		60.14(0.46)	12.51(0.13)	-21.19(0.01)	4.46(0.03)				
	7	7.94(0.90)	2.12(0.22)	-20.98(0.11)	3.41(0.26)		49.40(0.98)	10.28(0.17)	-21.17(0.02)	4.47(0.06)				
G348.55-0.97 (0,0)	2	5.10(0.28)	0.85(0.10)	-16.45(0.21)	5.38(0.51)		- (-)	- (-)	- (-)	- (-)				
	3	- (-)	- (-)	- (-)	- (-)		23.50(0.20)	2.99(0.03)	-16.21(0.02)	7.30(0.05)	b			
	5	- (-)	- (-)	- (-)	- (-)		7.09(0.88)	1.76(0.36)	-15.74(0.18)	3.09(0.51)				
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)				
G351.16+0.70 (-20,0)	2	11.28(0.15)	2.33(0.06)	-6.57(0.03)	4.33(0.08)	b	60.83(0.60)	10.42(0.07)	-6.34(0.01)	5.41(0.03)	b	br		
	3	14.76(0.17)	2.90(0.03)	-6.28(0.02)	4.55(0.04)	b	82.29(0.90)	11.56(0.03)	-5.89(0.01)	6.80(0.01)	b			
	5	5.65(0.33)	1.34(0.16)	-6.07(0.09)	3.41(0.34)		57.42(0.75)	8.34(0.10)	-6.10(0.02)	6.57(0.06)	b			
	7	- (-)	- (-)	- (-)	- (-)		43.40(1.08)	7.04(0.18)	-6.06(0.04)	5.69(0.11)				
G348.73-1.04 (20,0)	2	14.69(0.16)	2.90(0.05)	-12.42(0.02)	4.65(0.06)		66.04(0.31)	11.01(0.07)	-12.39(0.01)	5.61(0.03)	r	b		
	3	20.28(0.20)	4.18(0.03)	-12.29(0.01)	4.47(0.03)		71.37(0.39)	12.25(0.03)	-12.54(0.00)	5.43(0.01)	r			
	5	16.55(0.43)	2.91(0.09)	-11.96(0.05)	5.24(0.12)		68.12(0.59)	12.21(0.12)	-12.35(0.02)	5.16(0.04)				
	7	8.54(0.83)	1.48(0.27)	-11.68(0.18)	5.03(0.76)		59.64(0.98)	12.64(0.18)	-12.31(0.02)	4.37(0.05)				
G351.41+0.64 (0,0)	2	22.61(0.28)	4.52(0.05)	-6.63(0.02)	4.55(0.04)		92.82(0.70)	16.25(0.06)	-7.39(0.01)	5.37(0.02)		br		
	3	29.95(0.36)	5.68(0.04)	-6.67(0.01)	4.86(0.03)		111.36(0.49)	15.81(0.07)	-7.01(0.01)	6.64(0.02)	r			
	5	25.13(0.40)	4.49(0.09)	-6.82(0.03)	5.17(0.08)		112.98(0.59)	15.96(0.11)	-6.97(0.01)	6.66(0.04)	r			
	7	43.25(1.05)	6.50(0.19)	-6.76(0.06)	6.28(0.14)		135.63(1.34)	17.99(0.17)	-6.69(0.02)	7.18(0.05)				
G0.21-0.01 (0,0)	2	0.42(0.02)	0.61(0.27)	-2.72(0.04)	0.26(0.08)		- (-)	- (-)	- (-)	- (-)				
	3	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)				
	5	- (-)	- (-)	- (-)	- (-)		-0.05(0.42)	1.53(0.66)	-2.96(0.04)	0.24(0.08)				
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)				
G359.97-0.46 (0,0)	2	3.88(0.16)	1.23(0.09)	18.76(0.06)	2.60(0.14)		- (-)	- (-)	- (-)	- (-)				
	3	2.06(0.07)	0.40(0.03)	18.81(0.10)	4.41(0.24)		13.02(0.10)	2.92(0.03)	18.89(0.01)	4.15(0.03)				
	5	- (-)	- (-)	- (-)	- (-)		19.40(0.80)	3.47(0.18)	19.10(0.09)	5.16(0.21)				
	7	- (-)	- (-)	- (-)	- (-)		- (-)	- (-)	- (-)	- (-)				

included in the near infrared study of galactic masers by Testi et al. (1994).

The source G 351.41+0.64 is probably the best known object in our sample. The object is better known as NGC 6334I (in the ‘McBreen/Gezari convention’, see Appendix in Kuiper et al. 1995) or NGC 6334F (see e.g. De Pree et al. 1995). The source has already been mapped in CO (Dickel et al. 1977; Bachiller & Cernicharo 1990), C¹⁸O (Schwartz et al. 1989), HCO⁺ (Batchelor et al. 1984) and NH₃ (Kuiper et al. 1995).

CS has also been observed near NGC 6334I in transitions $J = 5 - 4$ and $J = 10 - 9$ (Hauschildt et al. 1993) but for the rest of our sample the present study comprises, to our knowledge, the first observations of CS transitions

higher than $J = 2 - 1$ as well as the first CS maps in any transition.

Since our sources are associated with both strong H₂O maser emission and strong IRAS sources the cores are evidently regions of high mass star formation. As most sources coincide with known compact HII regions the hydrogen recombination lines have also been observed towards many of them (see e.g. Wilson 1970; Caswell & Haynes 1987).

2.3. Data reduction

The basic data reduction was made using the GAG (*Groupe d'Astrophysique de Grenoble*) software which was also used for producing the maps. From the frequency switched spectra a baseline of order three to five was

Table 4. The IRAS point sources associated with the observed CS cores. The second column gives the positional difference between the centre point of the CS core as indicated with a cross in the channel maps, and the IRAS source

CS core	Δ (")	IRAS fluxes			
		12 μm	25 μm	60 μm	100 μm
308.00-0.25	20	7.92	106	573	873
308.92+0.12	18	251	601	2690	3570
309.92+0.48	20	76.4	667	3930	4410
311.94+0.18	126	22.6	79.7	1360	4470
316.37-0.37	0	10.1	42.5	752	1470
316.64-0.08	13	3.98	24.3	538	918
316.81-0.06	50	140	766	6840	16100
318.05+0.09	19	4.06	89.7	1130	2210
323.74-0.25	44	23.7	167	1950	3260
324.20+0.12	13	47.6	501	4820	6890
328.30+0.43	20	142	1210	11600	12400
329.04-0.21	58	6.31	4.24	332	1650
329.04-0.21	12	6.31	4.16	332	1650
330.88-0.36	19	20.8	237	6700	15100
331.00-0.19	52	2.98	210	10600	19200
331.28-0.18	34	36.2	237	2790	5720
332.65-0.63	13	104	656	5240	12400
332.83-0.55	24	105	1480	11400	20400
333.13-0.43	33	144	1520	12400	26700
333.60-0.22	33	2550	6810	5150	36400
337.40-0.40	22	8.49	134	3690	8450
337.91-0.47	50	192	1770	13300	24800
343.12-0.06	178	1.98	62.3	2620	6470
343.12-0.06	6	2.57	62.3	2620	6470
345.00-0.23	14	3.12	241	3660	7000
345.01+1.80	14	26.5	470	7140	13200
345.51+0.35	29	68.5	538	2700	18300
345.41-0.94	27	543	3880	12700	25800
348.55-0.97	53	19.6	98.3	1660	4340
348.73-1.04	19	328	1820	9910	35900
351.16+0.70	8	3.73	805	10500	19900
351.41+0.64	15	103	1400	11400	22100
359.97-0.46	5	27.6	228	1750	3750
359.97-0.46	154	2.4	4.83	1750	3750
0.21-0.01	43	4.45	61.4	595	8740

subtracted before folding. In some cases the poor quality of the baselines clearly increases the uncertainty of the results, but this affects only some of the CS(5–4) maps. All measurements of the centre positions of the clouds were made using position switching or wide beam switching (beam offset about $12''$). The subtraction of baselines of order one, or in some cases of order two, was sufficient.

3. Observational results

Figures 1 and 2 show the results of the mapping. Most sources were mapped in both CS(5–4) and C³⁴S(2–1),

thirteen clouds were mapped in CS(2–1) and a few clouds in CS(3–2) as well. The velocity intervals and contour levels are given in the figures. The positions of the masers (filled triangles) and the IRAS sources (stars) are also indicated.

The results of the single point measurements are shown in Fig. 3. The figure contains all CS spectra measured at the centre positions of the clouds i.e. the points of maximum emission as determined on the basis of the mapping. The spectra have been smoothed to correspond to the resolution of the spectrometer, about 80 kHz. Most CO(1–0) spectra are also shown.

The spectra at the central positions of the clouds were fitted with only one Gaussian component each although in some cases the spectra are clearly not well described with such fits. Therefore the fit results are, for some sources and transitions, clearly only indicative and should be treated as such.

The results from the fitting of the central position spectra are given in Table 3. The first column gives the offsets of the measured points with respect to the coordinates given in Table 2. The second column gives the J value for the upper level of each transition. Table 3 includes also the line areas which were calculated by directly summing the channel values, i.e. they are not results of the Gauss fits. Table 3 contains also information on some non-gaussian features of the spectra. Wing emission that exceeds 2σ noise level compared with the gaussian fit is marked with a letter r in case of a red wing and with b in case of a blue wing. Strong absorption features are indicated with letter a . The last column gives this information for the CO(1–0) line.

4. IRAS associations

The IRAS point source catalog was searched for infrared sources near the H₂O maser locations. Table 4 lists the point sources, the projected distance between the CS cloud centre and the IRAS source in arc seconds as well as the source flux in the IRAS bands. Most cores are associated with very strong infrared sources as this was one of the selection criteria used in the case of 26 of the altogether 33 sources. Figure 4 shows two colour-colour plots based on the IRAS fluxes. The first frame shows $\log[S(60)/S(12)]$ as function of $\log[S(25)/S(12)]$ and the criteria for ultracompact HII regions as given by Wood & Churchwell (1989). In the second frame the $\log[S(60)/S(25)]$ values are shown as the function of $\log[S(100)/S(60)]$. The selection criteria used by Richards et al. (1987) for compact molecular cores are indicated as a box. These figures show that most of our sources fulfill both given criteria. There are, however, also some exceptions, the most notable of which are G 329.04–0.21 and G 333.60–0.22. G 333.60–0.22 is a well known compact HII region and is in infrared one of the most luminous ones in the Galaxy (see e.g. Storey et al. 1989; Natta & Oliva 1985). G 329.04–0.21 is also

either a compact or ultra compact H II region (Habing & Israel 1979). Source G 0.21–0.01 is furthest above the box of compact molecular clouds of Richards et al. (1989) in Fig. 4b. This IRAS source is associated with an NH₃ clump mapped by Güsten et al. (1981) but the observed H₂O maser position is somewhat displaced from this.

5. Data analysis

5.1. LTE-analysis

The optical depths of all transitions $J = 2 - 1$, $J = 3 - 2$, $J = 5 - 4$ and $J = 7 - 6$ were first obtained in the usual manner from the ratio of the peak main beam temperatures assuming identical excitation temperatures and beam filling factors for both isotopes. By further assuming the terrestrial value $R=22.5$ for the abundance ratio between the two isotopes the optical depth of the rarer isotope τ_p was calculated from

$$\frac{T_{\text{MB}}^*(\text{C}^{34}\text{S})}{T_{\text{MB}}^*(\text{CS})} = \frac{1 - e^{-\tau_p}}{1 - e^{-\tau_p R}}. \quad (1)$$

If one takes into account the line broadening due to the optical depth (Phillips et al. 1979), the observed line width, ΔV , can be expressed in terms of the line width of the optically thin line, ΔV_0 , as

$$\Delta V = \frac{\Delta V_0}{\sqrt{\ln 2}} \sqrt{\ln \frac{\tau}{\ln \left[\frac{2}{1 + \exp(-\tau)} \right]}}. \quad (2)$$

This expression can be used to derive the optical depth from the ratio of the line area, $T_{\text{MB}}^* \Delta V$, for the two isotopes. We denote this value of the optical depth as τ_a .

The CS column densities have been calculated from the integrated line areas using the LTE approximation. The broadening of the lines due to optical depth was also taken into account by using the formula

$$N_u = \frac{3hc}{8\pi^3 \nu \mu^2} \frac{\int \tau(\nu) d\nu}{1 - e^{-\frac{h\nu}{kT}}} \quad (3)$$

for the column density of molecules on the upper level of the transition. The integral of the optical depth was calculated from

$$\int \tau(\nu) d\nu = f \frac{\int T_R d\nu}{J(T_{\text{ex}}) - J(T_{\text{bg}})} \quad (4)$$

with

$$J(T) = 1/(e^{\frac{h\nu}{kT}} - 1) \quad (5)$$

and the factor f was estimated numerically assuming a Gaussian line profile.

Table 5 gives the results of the LTE calculations. The optical depths τ_a and τ_p were calculated separately for different transitions $J = 2 - 1$, $3 - 2$, $5 - 4$ and $7 - 6$; similarly the column densities.

The densities and the cloud masses (see Table 6) were calculated by first estimating the cloud size from the C³⁴S(2–1) maps. The distances of the clouds were taken from Table 2 i.e. the values used are mostly kinematic distances calculated from the C³⁴S(2–1) line velocity using a flat rotation curve with $\Theta_0 = 220 \text{ km s}^{-1}$ and $R_0 = 8.5 \text{ kpc}$ (Fich et al. 1989). In some cases a value from the literature is used instead (see Table 2).

The adopted cloud sizes correspond to the area A where the line integral of C³⁴S(2–1) exceeds one half of its maximum value. Using a cloud diameter L derived from $L = \sqrt{4A/\pi}$ the density was calculated as $n = N_{\text{LTE}}(\text{H}_2)/L$. The mass is given by the formula $M = \mu m N_{\text{LTE}}(\text{H}_2)A$, where m is the mass of a hydrogen molecule and $\mu \approx 1.36$ the ratio between the total gas mass (including helium) and the hydrogen mass.

The values of cloud densities and masses are given in Cols. (4) and (5) of Table 6. The masses of strongly self-absorbed sources (e.g. G 345.00–0.23) are clearly underestimated.

The table also contains the virial masses that were calculated from the linewidths ΔV of CS(2–1) using the formula

$$M_{\text{vir}} = \frac{5}{3} \frac{\sigma^2 R}{G} = \frac{5}{16 \ln 2} \frac{L(\Delta V)^2}{G} \quad (6)$$

where σ is the velocity dispersion and G the gravitational constant. These values are in the last column of Table 6.

5.2. LVG models

The observations were also analyzed using a spherical LVG model. A value of $\mu = 1.96 \text{ D}$ was used for the electric dipole moment (Winnewisser & Cook 1968). The source coupling coefficients were estimated from the CS(2–1), C³⁴S(2–1), CS(5–4) and C³⁴S(5–4) maps by assuming a Gaussian beam with the beam widths given in The SEST Handbook (1993). These coefficients were interpolated for use with the $J = 3 - 2$ transitions and extrapolated to $J = 7 - 6$ transitions (see Table 2). For some sources an estimate for the kinetic temperature T_k is known from the literature. For the rest of the sources the CO(1–0) observations were used to get an approximate value for T_k . Figure 5 shows an example of the LVG modeling of one cloud at the kinetic temperature deduced from the CO observations. The lines correspond to the temperatures of the different transitions and error limits at 1σ due to statistical errors in deriving the peak temperatures. As in most cases the model errors exceed statistical errors i.e. there is no one unique solution within the error estimates. Furthermore the column density derived from the CS lines is systematically below the value derived from the C³⁴S lines.

Table 7 lists some results from the LVG modeling. Column (2) gives the adopted value of the kinetic temperature. These values have been estimated on the basis of the observed CO(1–0) antenna temperatures. For some

Table 5. Results from the LTE analysis of the CS observations. The values have been calculated separately from different transitions of CS and C³⁴S. τ_a and τ_p are the optical depths of C³⁴S calculated with different methods (see text). Column densities are calculated from the line integrals

Source	J	T_{ex} (K)	τ_p	τ_a	$\log N_L(\text{C}^{34}\text{S})$
308.00-0.25	2	7.2(0.2)	0.15(0.03)	0.23(0.09)	12.59(0.06)
	3	7.5(0.0)	0.20(0.01)	0.19(0.01)	12.39(0.01)
	5	11.4(9.0)	0.08(0.06)	0.25(0.20)	12.60(0.71)
	7	- (-)	- (-)	- (-)	- (-)
308.92+0.12	2	8.0(0.1)	0.23(0.01)	0.33(0.03)	12.66(0.02)
	3	9.5(0.0)	0.28(0.00)	0.54(0.02)	12.71(0.00)
	5	10.1(0.2)	0.21(0.02)	0.30(0.06)	12.69(0.03)
	7	14.0(0.2)	0.56(0.12)	0.09(0.05)	12.62(0.10)
309.92+0.48	2	6.4(0.1)	0.32(0.02)	0.52(0.06)	12.80(0.02)
	3	7.3(0.0)	0.32(0.01)	0.54(0.03)	12.70(0.01)
	5	6.5(0.2)	0.58(0.10)	0.16(0.05)	12.50(0.09)
	7	- (-)	- (-)	- (-)	- (-)
316.37-0.37	2	3.6(0.1)	0.18(0.05)	0.90(0.47)	12.82(0.10)
	3	- (-)	- (-)	- (-)	- (-)
	5	5.3(2.2)	0.91(0.47)	0.64(0.53)	14.41(0.57)
	7	- (-)	- (-)	- (-)	- (-)
316.64-0.08	2	3.5(0.4)	0.78(0.43)	0.33(0.34)	11.43(0.48)
	3	3.6(0.5)	0.58(0.38)	0.11(0.14)	- (-)
	5	6.5(3.4)	0.94(0.46)	0.49(0.45)	- (-)
	7	- (-)	- (-)	- (-)	- (-)
316.77-0.02	2	5.6(0.1)	0.18(0.02)	0.27(0.06)	12.62(0.04)
	3	7.8(1.0)	0.04(0.01)	0.03(0.02)	11.81(0.06)
	5	5.1(0.4)	1.13(0.21)	0.08(0.06)	12.26(0.44)
	7	- (-)	- (-)	- (-)	- (-)
316.81-0.06	2	7.1(0.1)	0.20(0.01)	0.28(0.04)	12.68(0.02)
	3	8.6(0.0)	0.15(0.00)	0.17(0.01)	12.36(0.01)
	5	7.6(0.1)	0.16(0.02)	0.34(0.09)	12.80(0.06)
	7	- (-)	- (-)	- (-)	- (-)
318.05+0.09	2	8.2(0.1)	0.22(0.01)	0.28(0.04)	12.71(0.02)
	3	9.3(0.0)	0.23(0.00)	0.31(0.01)	12.57(0.01)
	5	9.2(0.1)	0.29(0.03)	0.27(0.04)	12.70(0.03)
	7	- (-)	- (-)	- (-)	- (-)
323.74-0.25	2	5.5(0.1)	0.25(0.02)	0.54(0.08)	12.68(0.03)
	3	5.8(0.0)	0.21(0.01)	0.25(0.03)	12.52(0.01)
	5	7.2(0.6)	1.23(0.00)	0.04(0.03)	10.87(0.50)
	7	- (-)	- (-)	- (-)	- (-)
324.20+0.12	2	7.1(0.1)	0.25(0.01)	0.40(0.04)	12.89(0.01)
	3	8.3(0.0)	0.25(0.01)	0.28(0.01)	12.74(0.01)
	5	8.4(0.1)	0.31(0.03)	0.37(0.08)	13.11(0.03)
	7	- (-)	- (-)	- (-)	- (-)
328.30+0.43	2	8.2(0.1)	0.16(0.01)	0.32(0.03)	12.90(0.01)
	3	9.3(0.0)	0.18(0.00)	0.32(0.01)	12.71(0.01)
	5	10.6(0.8)	0.09(0.03)	0.15(0.07)	12.54(0.09)
	7	- (-)	- (-)	- (-)	- (-)
329.04-0.21	2	4.6(0.0)	0.42(0.04)	0.14(0.03)	12.83(0.02)
	3	5.2(0.0)	0.29(0.01)	0.21(0.01)	12.80(0.01)
	5	6.4(0.1)	0.18(0.03)	0.39(0.11)	13.25(0.06)
	7	- (-)	- (-)	- (-)	- (-)
331.00-0.19	2	9.9(0.0)	0.28(0.01)	0.55(0.02)	13.33(0.01)
	3	11.7(0.0)	0.26(0.00)	0.54(0.01)	13.13(0.00)
	5	11.8(0.1)	0.15(0.01)	0.25(0.03)	12.89(0.02)
	7	11.3(0.5)	0.35(0.16)	- (-)	- (-)
330.88-0.36	2	10.0(0.0)	0.31(0.01)	0.58(0.03)	13.25(0.01)
	3	10.6(0.0)	0.36(0.00)	0.61(0.02)	13.04(0.00)
	5	11.3(0.1)	0.16(0.01)	0.05(0.02)	12.46(0.03)
	7	- (-)	- (-)	- (-)	- (-)

Table 5. continued

Source	J	T_{ex} (K)	τ_{p}	τ_{a}	$\log N_{\text{L}}(\text{C}^{34}\text{S})$
331.28-0.18	2	6.2(0.0)	0.28(0.01)	0.68(0.08)	12.96(0.02)
	3	6.6(0.0)	0.34(0.01)	0.47(0.02)	12.75(0.01)
	5	6.3(0.1)	0.29(0.04)	0.60(0.17)	13.32(0.05)
	7	- (-)	- (-)	- (-)	- (-)
332.65-0.63	2	6.4(0.0)	0.37(0.01)	0.52(0.04)	12.93(0.01)
	3	7.8(0.0)	0.37(0.01)	0.60(0.02)	12.83(0.01)
	5	8.9(0.1)	0.25(0.01)	0.45(0.05)	12.75(0.03)
	7	- (-)	- (-)	- (-)	- (-)
332.83-0.55	2	10.2(0.0)	0.37(0.01)	1.00(0.04)	13.50(0.01)
	3	12.1(0.0)	0.46(0.00)	1.33(0.04)	13.40(0.00)
	5	14.9(0.1)	0.35(0.01)	0.74(0.04)	13.22(0.01)
	7	19.2(0.1)	0.44(0.01)	0.74(0.04)	13.41(0.01)
333.13-0.43	2	15.5(0.0)	0.38(0.00)	0.85(0.02)	13.74(0.00)
	3	14.7(0.0)	0.49(0.00)	1.24(0.02)	13.45(0.00)
	5	15.1(0.1)	0.25(0.01)	0.35(0.02)	12.94(0.01)
	7	14.6(0.1)	0.37(0.02)	0.65(0.06)	13.42(0.02)
333.60-0.22	2	10.8(0.1)	0.18(0.01)	0.30(0.02)	13.11(0.01)
	3	10.6(0.0)	0.20(0.00)	0.40(0.02)	12.93(0.01)
	5	11.1(0.1)	0.14(0.01)	0.30(0.04)	12.90(0.03)
	7	- (-)	- (-)	- (-)	- (-)
337.40-0.40	2	11.5(0.0)	0.31(0.01)	0.61(0.02)	13.32(0.01)
	3	12.7(0.0)	0.40(0.00)	0.78(0.01)	13.17(0.00)
	5	11.7(0.1)	0.30(0.01)	0.39(0.03)	12.96(0.01)
	7	- (-)	- (-)	- (-)	- (-)
337.91-0.47	2	11.1(0.1)	0.36(0.01)	1.46(0.11)	13.41(0.01)
	3	12.2(0.0)	0.58(0.01)	- (-)	- (-)
	5	15.5(0.1)	0.26(0.01)	0.33(0.02)	12.92(0.01)
	7	15.9(0.1)	0.58(0.03)	1.23(0.16)	13.66(0.03)
345.01+1.80	2	13.9(0.0)	0.22(0.00)	0.33(0.01)	13.26(0.00)
	3	14.1(0.0)	0.31(0.00)	0.46(0.01)	13.05(0.00)
	5	15.4(0.1)	0.21(0.01)	0.23(0.02)	12.76(0.01)
	7	- (-)	- (-)	- (-)	- (-)
343.12-0.06	2	6.3(0.0)	0.26(0.01)	0.40(0.04)	12.97(0.01)
	3	7.3(0.0)	0.33(0.01)	0.42(0.01)	12.97(0.01)
	5	9.9(0.1)	0.15(0.01)	0.14(0.02)	12.88(0.03)
	7	- (-)	- (-)	- (-)	- (-)
345.51+0.35	2	8.1(0.1)	0.28(0.01)	0.50(0.03)	13.03(0.01)
	3	9.7(0.1)	0.31(0.01)	0.57(0.03)	12.94(0.01)
	5	11.9(0.1)	0.22(0.01)	0.35(0.03)	12.75(0.02)
	7	- (-)	- (-)	- (-)	- (-)
345.00-0.23	2	4.8(0.0)	0.41(0.02)	0.41(0.03)	13.11(0.01)
	3	7.2(0.0)	0.31(0.00)	0.35(0.01)	13.02(0.00)
	5	10.3(0.1)	0.19(0.01)	0.22(0.03)	12.91(0.02)
	7	- (-)	- (-)	- (-)	- (-)
345.41-0.94	2	14.3(0.1)	0.29(0.00)	0.74(0.03)	13.36(0.00)
	3	17.4(0.0)	0.38(0.00)	0.87(0.01)	13.22(0.00)
	5	17.9(0.1)	0.30(0.01)	0.50(0.03)	12.87(0.01)
	7	17.2(0.1)	0.23(0.02)	0.35(0.05)	12.98(0.03)
351.16+0.70	2	13.7(0.1)	0.25(0.00)	0.43(0.01)	13.31(0.00)
	3	15.4(0.0)	0.29(0.00)	0.39(0.01)	13.09(0.00)
	5	13.7(0.1)	0.17(0.01)	0.12(0.03)	12.62(0.02)
	7	- (-)	- (-)	- (-)	- (-)
348.73-1.04	2	14.3(0.1)	0.31(0.00)	0.60(0.02)	13.45(0.00)
	3	16.1(0.0)	0.42(0.00)	1.00(0.02)	13.31(0.00)
	5	17.6(0.1)	0.27(0.01)	0.73(0.04)	13.03(0.01)
	7	20.9(0.6)	0.11(0.02)	0.27(0.07)	12.80(0.04)
351.41+0.64	2	19.5(0.0)	0.33(0.00)	0.69(0.01)	13.72(0.00)
	3	19.7(0.1)	0.44(0.00)	0.86(0.01)	13.48(0.00)
	5	21.4(0.1)	0.33(0.00)	0.60(0.02)	13.12(0.01)
	7	25.3(0.1)	0.45(0.01)	1.34(0.10)	13.49(0.01)

Fig. 4. The colour-colour diagrams of the IRAS sources associated with the CS cores. The figures contain all IRAS sources marked in the CS maps. **a)** The colour-colour diagram $(25-12) \times (60-12)$ of the IRAS sources. The selection criterion for ultra compact HII regions of Wood & Churchwell (1989) is also indicated. **b)** The $(60-25) \times (100-60)$ colour-colour diagram. The box indicates the selection criteria for compact molecular clouds given by Richards et al. (1987)

sources the value is uncertain because of either the complexity or the poor quality of the CO spectrum. These are marked with a question mark in the table. The following columns give the total gas densities and the ^{32}CS column densities derived separately from the CS transitions $J = 2 - 1$ and $J = 5 - 4$ and the C^{34}S transitions $J = 2 - 1$ and $J = 5 - 4$.

The errors were estimated by adding 10% calibration error to the statistical errors of the temperature fits and drawing the corresponding error bands for all transitions in the (n, N_{L}) plane as shown in Fig. 5. Since the error

Table 6. The densities and cloud masses calculated in LTE approximation from the lines $\text{C}^{34}\text{S}(2-1)$ and $\text{CS}(2-1)$. The last column gives the virial masses of the cores

Source	d (kpc)	Size ($''$)	$\log n$ cm^{-3}	M ($M_{\odot}$)	M_{vir} ($M_{\odot}$)
G308.00-0.25	2.1	50.00	4.5	230	1213
G308.92+0.12	4.0	54.90	4.2	1105	1635
G309.92+0.48	4.0	69.70	4.3	2322	2618
G316.37-0.37	12.0	30.00	3.9	2518	5072
G316.77-0.02	3.1	96.55	3.9	1186	5279
G316.81-0.06	3.0	85.45	4.0	1060	2655
G318.05+0.09	3.7	74.55	4.0	1354	2392
G323.74-0.25	3.5	85.80	3.9	1338	3105
G324.20+0.12	6.9	53.90	4.4	8595	6877
G328.30+0.43	8.5	70.70	4.0	12971	8281
G329.04-0.21	3.1	59.45	4.5	1139	18646
G331.00-0.19	5.7	62.65	4.8	18336	12366
G330.88-0.36	4.2	71.50	4.8	11336	5966
G331.28-0.18	5.5	73.10	4.6	14968	6759
G332.65-0.63	3.6	72.90	4.4	3002	5120
G332.83-0.55	4.0	61.35	5.0	9431	7195
G333.13-0.43	3.7	58.00	5.3	12264	5672
G333.60-0.22	3.6	79.80	4.4	3344	7025
G337.40-0.40	3.4	69.35	4.9	6518	3943
G337.91-0.47	3.3	66.40	4.9	5628	1642
G345.01+1.80	2.1	78.10	4.9	2020	2945
G343.12-0.06	3.2	40.00	5.0	1137	4824
G345.51+0.35	2.5	57.85	4.8	1142	2441
G345.00-0.23	3.2	54.50	4.7	1482	21706
G345.41-0.94	2.8	61.05	4.9	2730	1251
G351.16+0.70	2.1	72.10	5.1	2384	2227
G348.73-1.04	2.4	66.95	5.2	4000	2602
G351.41+0.64	1.7	92.80	5.2	3957	2310

limits were usually found to be small compared to the differences between results derived from different pairs of transitions the error estimates are given in Table 7 only when they exceed 0.1 units.

6. Discussion

Most CS cores appear almost spherical in our maps and most do not show strong velocity gradients. In G 351.41+0.64 one can clearly see the velocity difference between NGC 6334I (the centre of the map) and NGC 6334I-N (Schwartz et al. 1989) in the northern part of the map. Among the other sources a change in radial velocity can be seen only in four cases: G 309.92+0.48, G 316.77-0.02, G 316.81-0.06 and G 328.30+0.43. The lack of velocity gradients can be partly due to the limited sizes of our maps. The map G 351.41+0.64 is the largest of them and in most other cases only the densest core is mapped.

The position of maximum emission is always the same for all observed lines, within $15''$. In some cases (e.g.

Fig. 5. An example (G 332.83–0.55) of the results from the LVG analysis. The different lines give the one σ error bands (statistical errors plus 10% for calibration errors) for the radiation temperature measurements. In the figure the contours are drawn for CS(2–1) (thick continuous line), CS(3–2) (thick dashed line), CS(5–4) (thick dotted line), CS(7–6) (thick dash-dotted line), C³⁴S(2–1) (thin line), C³⁴S(3–2) (thin dashed line), C³⁴S(5–4) (thin dotted line) and C³⁴S(7–6) (thin dash-dotted line). An abundance ratio of 22.5 is assumed for the two isotopes

G 330.88–0.36) one can see a small displacement between the different transitions and isotopes but this is never more than only marginal.

The differences between the profiles of different lines are more clear. The lower CS transitions show in most cases some effects of the optical depth saturation ranging from slightly flattened line profiles (e.g. G 308.00–0.25) to strongly self absorbed lines as in G 329.04–0.21 or in G 345.00–0.23 where even the CS(5–4) line is clearly self-absorbed. The absorption features can exist either on the redshifted (e.g. G 337.91–0.47) or on the blueshifted side of the line (e.g. G 345.00–0.23). Many sources show also wide blue and red wings (e.g. G 309.92+0.48, G 324.20+0.12).

In Fig. 6 we present the distribution of the observed radial velocity differences between the water masers and the CS line emission. The data contain the velocities of those H₂O masers that have been marked in our CS maps, and the center velocities of C³⁴S(2–1) from Gauss fits. The distribution seems to be asymmetric with respect to zero in the sense that the maser radial velocities are mainly smaller than the velocity of the CS cloud. The difference could be due to beaming effects as suggested by Zinchenko

Table 7. Results from the LVG analysis. Total gas density and the column density of the main isotope have been calculated from CS and C³⁴S observations separately. Numbers in parenthesis indicate the uncertainty of the last digit when it exceeds 1

Source	T_{kin} (K)	CS		C ³⁴ S	
		$\log n$ (cm ⁻³)	$\log N_L$ (cm ⁻²)	$\log n$ (cm ⁻³)	$\log N_L$ (cm ⁻²)
308.00-0.25	30	5.8	13.5	5.5(3)	14.1(2)
308.92+0.12	40	5.8	13.7	5.7	14.3
309.92+0.48	20	6.0	13.5	6.3	14.3
311.94+0.18	-	-	-	-	-
316.37-0.37	10?	>6.0	12.8	-	-
316.64-0.08	15?	6.5(3)	12.7	-	-
316.77-0.02	30	5.4	13.3	6.3(4)	13.9(2)
316.81-0.06	35	5.7	13.4	5.7	14.1
318.05+0.09	35	5.8	13.7	5.8	14.2
323.74-0.25	20	6.0	13.2	-	-
324.20+0.12	-	-	-	-	-
328.30+0.43	40	5.8	13.6	5.6	14.0
329.04-0.21	15	6.9	13.1	6.3	14.1
331.00-0.19	30	5.9	13.8	5.7	14.6
330.88-0.36	45	5.7	13.8	5.4	14.7
331.28-0.18	20	6.1	13.3	6.0	14.3
332.65-0.63	35	6.0	13.4	5.8	14.3
332.83-0.55	30	6.3	13.8	6.1	14.7
333.13-0.43	50	5.5	14.2	5.3	14.8
333.60-0.22	50	5.5	13.7	5.5	14.2
337.40-0.40	20	6.0	14.1	6.1	14.7
337.91-0.47	10?	-	-	-	-
345.01+1.80	45	5.7	14.0	5.7	14.6
343.12-0.06	25	6.5	13.4	6.0	14.4
345.51+0.35	35	6.1	13.7	5.8	14.4
345.00-0.23	10?	-	-	-	-
345.41-0.94	55	5.7	14.1	5.7	14.7
348.55-0.97	-	-	-	-	-
351.16+0.70	45	5.6	14.0	5.4	14.7
348.73-1.04	60	5.7	14.1	5.7	14.8
351.41+0.64	55	5.7	14.2	5.7	14.8
0.21-0.01	-	-	-	-	-
359.97-0.46	-	-	-	-	-

et al. (1995) or due to obscuration of the maser sources behind the cloud core. However, the difference between the velocities of CS emission and H₂O masers is statistically not very significant in this sample. The probability that the mean of $V_{\text{H}_2\text{O}} - V_{\text{CS}}$ is less than zero is only 59%. Moreover, the H₂O emission usually contains many maxima with widely varying velocities. Since we have only considered the velocity of the strongest component the result does not necessarily reflect the distribution of all maser sources associated with the molecular core.

The LVG calculation gives clearly different results depending on the transitions used. Of course, one cannot

Fig. 6. The distribution of the velocity differences between H₂O masers and the CS emission as determined from the C³⁴S(2–1) lines

expect similar results since different transitions probe different volumes of the emitting gas. The isotope C³⁴S gives, however, systematically higher values for the total column density than CS. Since the terrestrial value of $R=22.5$ was used as the abundance ratio between the isotopes, the results of the LVG analysis seem to indicate a smaller ratio, in fact less than 5.0. This can be only partly attributed to underestimated kinetic temperatures and uncertainties in the determination of the source coupling coefficients. There is already some evidence for a lower value e.g. Mundy et al. (1986) obtained values $R=9-17$.

7. Summary and conclusions

1. We have observed 33 southern molecular cores associated with H₂O masers in several CS and C³⁴S lines. The clouds have been mapped mainly in CS(2–1), CS(5–4) and C³⁴S(2–1). All central positions of the clouds have been observed in both isotopes in transitions $J = 3-2$ and $J = 5-4$ as well as in C³⁴S(2–1). Some selected clouds were also mapped in CS(3–2). CS(7–6) was observed in 14 and C³⁴S(7–6) in seven clouds.
2. The maps of emission from different transitions and from different isotopes show a closely similar distribution. The positional differences in the peak emission do not exceed 15".
3. We have calculated the optical depths of the C³⁴S lines and the column densities in the LTE approximation. All observations have also been analysed through LVG modeling. The total column densities calculated with LVG models using the C³⁴S isotope exceed the values calculated from the main isotope when an isotope ratio $R=22.5$ (terrestrial value) has been assumed. The results give support to a much lower value, $R<10$.

4. The masses calculated with the LTE approximation are mainly in agreement with the virial masses. The mean density of the gas along the line of sight is typically $10^4-10^5 \text{ cm}^{-3}$. The LVG models do not produce clearly increasing values for density with higher transitions.

This paper has presented the observations and the basic analysis of the CS observations. The data will also be analysed with the aid of three dimensional Monte Carlo simulation. The effects of the clumpy structure of the emitting gas will be of special interest during this analysis.

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Fig. 1. The maps of integrated main beam temperature for transitions $CS(2-1)$, $CS(3-2)$ and $C^{34}S(2-1)$. The source name and the line are indicated above each group of four figures. The integrated velocity interval is given above each frame and the contour levels in units of $K km s^{-1}$ are indicated inside the frames. H_2O -maser positions are marked with triangles and IRAS point sources with stars. A cross marks the position used for further one point measurements

Fig. 1. continued

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Fig. 1. continued

Fig. 2. The maps of integrated main beam temperature for the transition $\text{CS}(5-4)$. The integrated velocity intervals and the contour values in units of K km s^{-1} are indicated inside the frames. H_2O -maser positions are marked with triangles and IRAS point sources with stars. A cross marks the position used for further one point measurements

Fig. 2. continued

Fig. 2. continued

Fig. 3. The observed CS and $C^{34}S$ spectra towards the positions of peak emission. Positions differ from the zero offset positions given in Table 2. The offsets from these coordinates are given in the figure and the positions are also indicated with crosses in Figs. 1 and 2

Fig. 3. continued

Fig. 3. continued

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