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A review of H_2CO 6 cm masers in the Galaxy

E. Araya[1,2], **P. Hofner**[1,2] **and W. M. Goss**[2]

[1]National Radio Astronomy Observatory, P.O. Box 0, Socorro, NM 87801, USA
[2]New Mexico Institute of Mining and Technology, Physics Department, 801 Leroy Place,
Socorro, NM 87801, USA
email: earaya@nrao.edu

Abstract. We present a review of the field of formaldehyde (H_2CO) 6 cm masers in the Galaxy. Previous to our ongoing work, H_2CO 6 cm masers had been detected in the Galaxy only toward three regions: NGC 7538 IRS1, Sgr B2, and G29.96–0.02. Current efforts by our group using the Very Large Array, Arecibo, and the Green Bank Telescope have resulted in the detection of four new H_2CO 6 cm maser regions. We discuss the characteristics of the known H_2CO masers and the association of H_2CO 6 cm masers with very young regions of massive star formation. We also review the current ideas on the pumping mechanism for H_2CO 6 cm masers.

Keywords. masers, stars: formation, ISM: molecules, HII regions, radio lines: ISM

1. Introduction

Formaldehyde (H_2CO) was the first organic polyatomic molecule discovered in the interstellar medium. H_2CO is an asymmetric top molecule, however the asymmetry is small; the moment of inertia for rotation of the molecule about the ‘c’ axis is slightly greater than the moment of inertia about the ‘b’ axis (Figure 1a). In the case of ortho-H_2CO (i.e., when the nuclear spins of the hydrogen atoms are parallel), the small asymmetry causes splitting of the rotational states into closely spaced energy levels known as K-doublets (Figure 1b). Electric dipole transitions between low energy K-doublets ($\Delta K_c = \pm 1$, $\Delta J = 0$, Q-branch transitions, e.g., Townes & Schawlow 1975) result in radio-frequency lines.

The first detection of H_2CO was reported by Snyder *et al.* (1969). They found H_2CO absorption in the 6 cm line ($J_{K_a K_c} = 1_{11} - 1_{10}$; $\nu_o = 4829.6596$ MHz for the F=2–2 hyperfine component, Tucker *et al.* 1971), i.e., the K-doublet transition from the lowest ortho-H_2CO energy levels (Figure 1b). Soon after the first detection of H_2CO, Palmer *et al.* (1969) discovered H_2CO 6 cm absorption against the 2.7 K Cosmic Microwave Background (CMB), implying an excitation temperature $T_{ex} < 2.7$ K for the H_2CO 6 cm K-doublet in Galactic dark clouds. The detection of H_2CO absorption against the CMB (the so called *anomalous* absorption of H_2CO) required an anti-inversion (cooling) mechanism that was promptly recognized to be caused by H_2 collisions (Townes & Cheung 1969, Garrison *et al.* 1975, Evans *et al.* 1975a, Green *et al.* 1978).

Almost four decades after its discovery, the H_2CO 6 cm line has been detected toward hundreds of regions in the Galaxy. H_2CO has been observed in *absorption* against the CMB, Galactic and extragalactic radio continuum sources (e.g., Rodríguez *et al.* 2006, Young *et al.* 2004, Sewiło *et al.* 2004b, Watson *et al.* 2003, Araya *et al.* 2002, Downes *et al.* 1980). In sharp contrast to the ubiquitous H_2CO 6 cm absorption line, H_2CO 6 cm *emission* is an extremely rare phenomenon: H_2CO 6 cm emission has been confirmed as megamaser emission only toward four extragalactic objects (Araya *et al.* 2004a, Baan private communication), found as thermal emission only toward the Orion BN/KL region

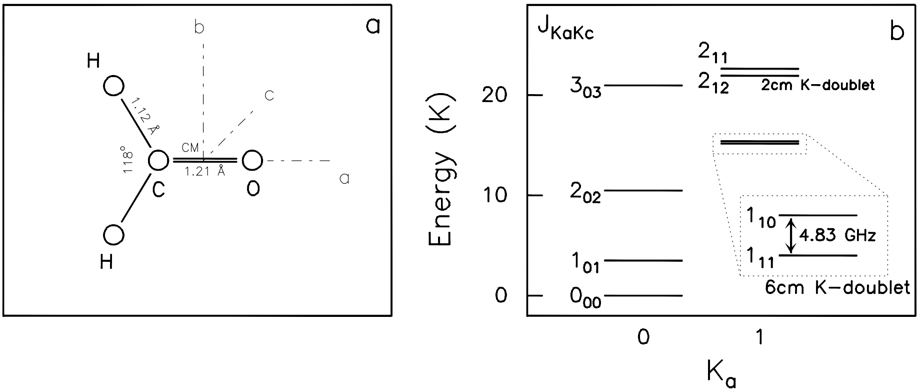

Figure 1. *Left:* Geometry of the H_2CO molecule (Townes & Schawlow 1975; for aesthetic reasons we show a 'left-handed' a-b-c coordinate axis). *Right:* H_2CO energy level diagram of states with $E(J_{K_a K_c}) < 30\,K$ (Jaruschewski *et al.* 1986).

(Zuckerman *et al.* 1975, see also Araya *et al.* 2006b)†, and only seven Galactic maser regions have been reported (Forster *et al.* 1980, Whiteoak & Gardner 1983, Pratap *et al.* 1994, Araya *et al.* 2005, 2006a, 2007 *in prep.*). In this article we review the field of H_2CO 6 cm masers: the characteristics of the known masers, the astrophysical environments where the masers are found, and the current ideas on the excitation of H_2CO 6 cm masers.

2. H_2CO 6 cm maser surveys

The first H_2CO maser region detected was NGC 7538. Using the Effelsberg 100 m telescope, Downes & Wilson (1974) detected a double peak emission profile superimposed with an absorption feature (see Figure 2 for a recent spectrum of the maser). Aperture synthesis observations by Forster *et al.* (1980) and Rots *et al.* (1981) demonstrated the maser nature of the H_2CO 6 cm emission. Approximately 10 years after the detection of H_2CO emission in NGC 7538, Whiteoak & Gardner (1983) using the VLA detected maser emission from five locations in Sgr B2. Mehringer *et al.* (1994) conducted further VLA observations ($\theta_{syn} \sim 1''$) of the region and detected four more H_2CO maser sites, resulting in a total of nine H_2CO 6 cm maser sites in Sgr B2.

Since the detections by Downes & Wilson (1974) and Whiteoak & Gardner (1983), there have been six surveys specifically focused on the search for H_2CO masers (see Table 1). Given the ubiquitous H_2CO 6 cm absorption in molecular clouds (e.g., Watson *et al.* 2003) and the weak intensity of the known H_2CO 6 cm masers (see §3), surveys for H_2CO maser emission have been conducted using large single dish radio telescopes and interferometers to detect weak lines (~ 100 mJy) and to avoid confusion due to H_2CO absorption.

The survey by Forster *et al.* (1985) focused on OH maser sources, including not only massive star forming regions but also OH maser stars. The survey yielded no new detections. Pratap *et al.* (1994) and Mehringer *et al.* (1995) conducted observations of active regions of massive star formation known to harbor ultra-compact H II regions as well as

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† H_2CO 6 cm thermal emission was also reported toward comets Halley and Machholz (1988j) (Snyder *et al.* 1989, 1990; see however Bockelée-Morvan & Crovisier 1992). Emission of the 2 cm K-doublet is also rare (Martín-Pintado *et al.* 1985, Johnston *et al.* 1984, Loren *et al.* 1983, Wilson *et al.* 1982, Evans *et al.* 1975b), and maser emission from the 2 cm transition has not been observed.

Table 1. H_2CO 6 cm Galactic masers

Reference	Sample	Telescope	Detections	Selection Criteria
Downes & Wilson (1974)	1	Effelsberg	NGC 7538*	NGC 7538
Whiteoak & Gardner (1983)	1	VLA	Sgr B2*	Sgr B2
Forster *et al.* (1985)	19	WSRT	—	OH Maser Sources
Pratap *et al.* (1994)	7	VLA	G29.96−0.02*	UCHII Regions
Mehringer *et al.* (1995)	22	VLA	—	MSFR
Araya *et al.* (2004b)	15	Arecibo	IRAS 18566+0408	Weak Cont. MSFR
Araya *et al.* (2007a)	58	GBT/VLA	G23.71−0.20*	MSFR, H_2CO Spectra
Araya *et al.* (2007 *in prep.*)	14	VLA	G23.01−0.41 & G25.83−0.18	MSFR, H_2CO Spectra

* Sources that have been observed with MERLIN and/or the VLBA (see §3).

maser emission from a variety of molecules. Out of 29 sources observed with the VLA in these surveys, only G29.96−0.02 was found to harbor H_2CO maser emission.

Recently, Araya and collaborators conducted three surveys exploring different search strategies: 1. they observed regions of weak radio continuum to reduce confusion due to H_2CO absorption and focused on massive star forming regions thought to be in an evolutionary stage prior to the ultra-compact H II phase (Arecibo and GBT; Araya *et al.* 2004b, 2007a), 2. they observed massive star forming regions independently of the radio continuum to search for strong and potentially variable masers (GBT; Araya *et al.* 2007a), and 3. they conducted VLA observations of sources that had been previously observed with the GBT or Arecibo and that showed complex absorption line profiles consistent with H_2CO emission blended with absorption (Araya *et al.* 2007a, 2007 *in prep.*). The three surveys resulted in detection of four new maser regions: IRAS 18566+0408 (Araya *et al.* 2004b, 2005), G23.71−0.20 (Araya *et al.* 2006a, 2007a), G23.01−0.41 and G25.83−0.18 (Araya *et al.* 2007 *in prep.*).

3. Physical properties

H_2CO masers are weaker in comparison with most OH, H_2O, and CH_3OH masers; the flux density range of the known H_2CO masers is between 10 mJy (for the maser in IRAS 18566+0408; see the poster contribution by Araya *et al.* in these proceedings) and ∼2 Jy (for the brightest masers in Sgr B2 and NGC 7538; Hoffman *et al.* 2007, Araya *et al.* 2007a), while most masers have flux densities of the order of ∼ 100 mJy. Two maser regions have been observed at ∼ 50 mas angular resolution with MERLIN: NGC 7538 (Hoffman *et al.* 2003), and G23.71−0.20 (Araya *et al.* 2007 *in prep*). MERLIN observations recover most ($\gtrsim$ 70%) of the flux density detected at lower angular resolutions, and the masers are unresolved or barely resolved. Araya *et al.* (2007 *in prep.*) find a brightness temperature $\gtrsim 10^5$ K for the maser in G23.71−0.20.

Three sources have been observed at ∼ 10 mas angular resolution with the VLBA: NGC 7538, G29.96−0.02, and Sgr B2. Hoffman *et al.* (2003) report brightness temperatures between 10^6 and 10^8 K for the masers in G29.96−0.02 and NGC 7538. Two of the nine maser components in Sgr B2 were observed with the VLBA by Hoffman *et al.* (2007). They also found brightness temperatures in the 10^8 K range. In general, only a fraction of the flux density is recovered with the VLBA, and as in the case of other astrophysical masers, the lines are narrower in the VLBA observations compared with VLA or single dish observations. Hoffman *et al.* (2007) discuss these results in the context of a core-halo model, where the maser brightness distribution is the result of the superposition of two Gaussian components, one compact (∼ 10 mas) saturated component that is

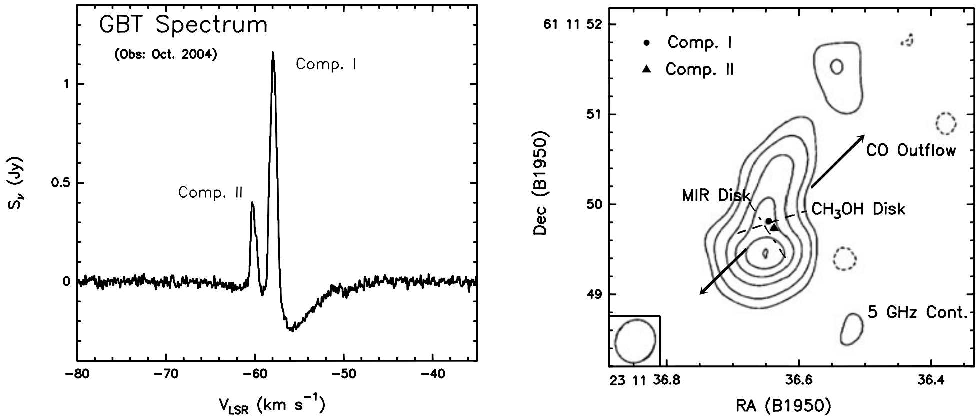

Figure 2. *Left:* H_2CO 6 cm spectrum of NGC 7538 IRS1 (Araya *et al.* 2007a). Two maser components are blended with an H_2CO absorption line. *Right:* Location of the two H_2CO maser components (dot and triangle) superimposed on the 6 cm radio continuum in NGC 7538 IRS1 (Rots *et al.* 1981). Re-reduction of the Rots *et al.* (1981) data using a more accurate position of the phase calibrator results in H_2CO maser positions that are consistent with the VLBA and MERLIN values reported by Hoffman *et al.* (2003). The direction of the CO (2–1) outflow is indicated by arrows (Davis *et al.* 1998), and two possible orientations of a circumstellar disk in the region are shown with dot-dashed (MIR Disk, De Buizer & Minier 2005) and dashed (CH_3OH Disk, Pestalozzi *et al.* 2004) lines.

detected with the VLBA ($T_b \sim 10^8$ K), and one extended and unsaturated halo that is resolved out by the VLBA observations ($T_b \sim 10^5$ K). Based on the VLBA and MERLIN results, the projected physical size of the masers is between 30 and ∼ 200 AU, while the maser gains range between −6 and −12; the emission is unpolarized within the current sensitivity limits (Hoffman *et al.* 2003, 2007).

4. Line profiles and velocity gradients

With the exception of Sgr B2 where nine H_2CO maser spots have been found (some of them showing multiple-peaked and broad line profiles, e.g., Mehringer *et al.* 1994), the H_2CO maser line profiles are relatively simple. A peculiar characteristic of the known H_2CO maser regions is that double peaked profiles are very common; double peaked profiles have been detected in NGC 7538 (e.g., Figure 2), G29.96−0.02 (Pratap *et al.* 1994, Hoffman *et al.* 2003), IRAS 18566+0408 (Araya *et al.* 2007c), G25.83−0.18 (Figure 3), and possibly toward G23.01−0.41 (Araya *et al.* 2007 *in prep.*). In all of these cases the velocity separation of the maser components is less than 3 km s^{-1}, and the components are (in most cases) spatially coincident in VLA observations. The double peaked profiles are unlikely caused by the hyperfine structure of the 6 cm H_2CO transition. Recent high spectral resolution (0.1 km s^{-1} channel width) VLA observations of the masers in G23.01−0.41 and G25.83−0.18 (Araya *et al.* 2007 *in prep.*) show very narrow maser components (FWHM∼0.3 km s^{-1}), possibly due to the line narrowing effect of unsaturated masers.

In the case of the H_2CO masers in NGC 7538, the components are oriented in a NE–SW direction, with a projected separation of 79 mas (240 AU). VLBA observations of the red shifted component show a 1900 km s^{-1} pc^{-1} velocity gradient also in a NE–SW orientation (see figures 4 and 5 of Hoffman *et al.* 2003).

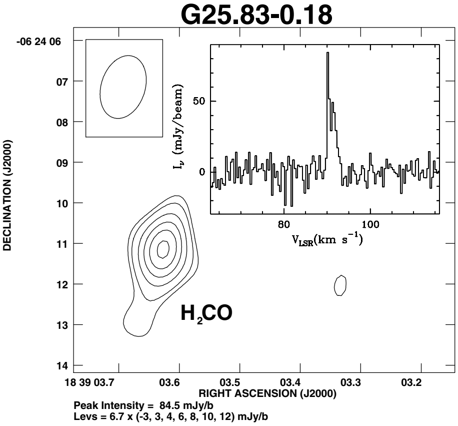

Figure 3. H_2CO 6 cm maser emission in G25.83−0.18 detected with the VLA by Araya *et al.* (2007 *in prep.*). Excluding the masers in Sgr B2, five out of six sources show double peak profiles.

5. Variability

Prior to the recent work by Araya *et al.* (2007c), variability of H_2CO masers had been observed only in some of the Sgr B2 masers and in the NGC 7538 masers; only long time-scale variability ($>$ 1 yr) had been reported (e.g., Mehringer *et al.* 1994, Hoffman *et al.* 2003). In the case of the variability of the H_2CO masers in NGC 7538 and based on the similar variability-rate of the two maser components (Figure 4 *left panel*), Araya *et al.* (2007a) suggested that the variability of the masers may be caused by a perturbation that took $\sim$ 14 yr† to reach Comp. II after having reached Comp. I. If that were the case, an increase in the rate-of-change of the intensity of Comp. II would be expected after the year 2009. The variability of the two maser components could be related to the precessing jet reported by Kraus *et al.* (2006).

Araya *et al.* (2007c) have recently found a new type of H_2CO maser variability, namely, short term flares. Using Arecibo, VLA, and GBT data, Araya *et al.* (2007c) reported occurrence of an outburst of the H_2CO 6 cm maser in IRAS 18566+0408; the maser flare lasted for less than three months and decayed to the pre-flare intensity within a month. The H_2CO maser in IRAS 18566+0408 has a double peak profile. Both components varied by approximately the same factor and in the same time period; no change in the line widths and peak velocities was detected. Araya *et al.* (2007c) discussed the implications of the flare on the possible excitation mechanism of the maser, and concluded that if the flare were due to a maser gain change, then (independently of the saturation state of the maser) the pumping mechanism is likely radiative; whereas if the maser is unsaturated, then a change in the background 6 cm radio continuum might have been amplified by the maser gas (independently on the maser pumping mechanism).

A monitoring program of the maser with Arecibo has recently resulted in the detection of a second H_2CO maser burst in IRAS 18566+0408 (Figure 4, *right panel*); showing that the flares are recurrent in this source. Araya and collaborators are also monitoring the CH_3OH 6.7 GHz masers in the region, and found that one of the CH_3OH maser components showed the same outburst as the H_2CO 6 cm maser (Figure 4, *right panel*). The CH_3OH maser peak that showed the flare does not correspond in velocity to the H_2CO maser, hence the masers originate in different regions. It is possible that both masers are unsaturated and that a change in the background radio continuum was amplified by the

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† Curiously, the period of the long-term variability of H_2O masers in the region reported by Lekht *et al.* (2004) is $\sim$ 13 yr.

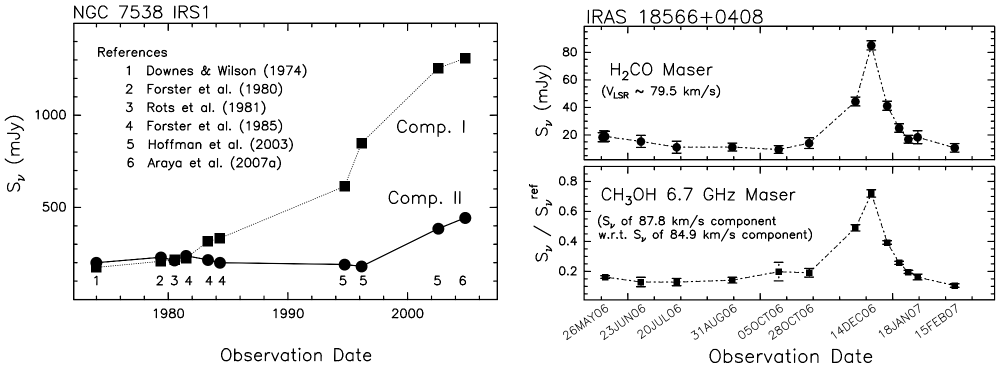

Figure 4. *Left:* Long term variability of the H_2CO masers in NGC 7538. The similar intensity rate-of-change of the two maser components after the onset of the variability lead Araya *et al.* (2007a) to propose that the variability of both components may have a common origin. *Right:* Arecibo light-curve of the second short-term H_2CO maser flare detected (Araya *et al.* 2007 *in prep*). Araya and collaborators are also monitoring with Arecibo the CH_3OH 6.7 GHz masers; one of the CH_3OH maser components showed the same outburst as the H_2CO 6 cm maser (see the poster contribution by Araya and collaborators in these proceedings).

CH_3OH and H_2CO masers (see poster contribution by Araya and collaborators in these proceedings).

Variability of some of the H_2CO masers in Sgr B2 has also been found (Mehringer *et al.* 1994, Hoffman *et al.* 2007); however the available data are insufficient to establish whether the masers show long term variability or maser flares as in IRAS 18566+0408.

6. Astrophysical environments: H_2CO masers pinpointing disk candidates around young massive stars

Motivated by the detection of H_2CO maser emission toward NGC 7538 and Sgr B2 (both massive star forming regions) the subsequent surveys for H_2CO maser emission have been conducted mainly toward regions of massive star formation (Table 1). However, H_2CO 6 cm observations have also been carried out toward a number of non-massive star forming regions and no new maser has been reported (e.g., Araya *et al.* 2006b, 2003; Rodríguez *et al.* 2006; Young *et al.* 2004). Thus, H_2CO 6 cm masers appear to be exclusively associated with massive star formation.

Except for some of the H_2CO masers in Sgr B2, H_2CO masers are mostly found along line-of-sights devoid of strong compact radio continuum (though continuum regions may be found nearby, e.g., Pratap *et al.* 1994); they are located close to CLASS II CH_3OH and H_2O masers (in many cases coincident within a synthesized beam), deeply embedded infrared sources and/or other evidence of massive star formation such as hyper-compact H II regions and hot molecular cores (e.g., Araya *et al.* 2007b, 2006a, 2005; Hoffman *et al.* 2007, 2003; Pratap *et al.* 1994). Thus, H_2CO masers appear to trace young massive stellar objects before the onset of a bright ultra-compact HII region. Moreover, in the case of three of the H_2CO maser sources that have been studied in detail, there is some evidence for an association between H_2CO maser emission and circumstellar disks:

– **G29.96−0.02** is a massive star forming region that harbors an ultra-compact HII region and a hot molecular core (e.g., Cesaroni *et al.* 1994). The H_2CO maser is coincident with the hot molecular core (Pratap *et al.* 1994). Hot molecular cores are believed to be an evolutionary phase prior to the formation of an ultra-compact H II region (e.g.,

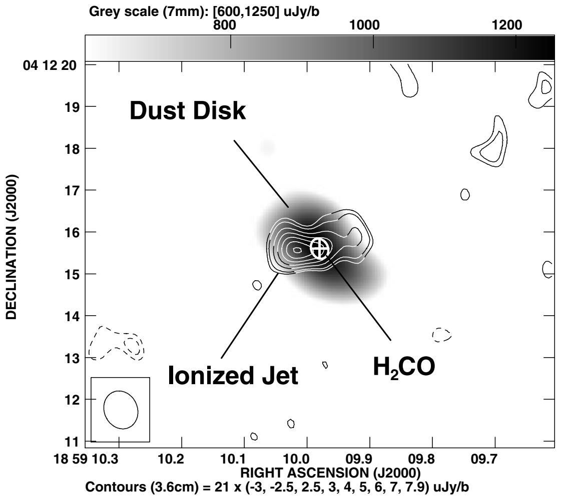

Figure 5. Location of the H_2CO 6 cm maser in IRAS 18566+0408 with respect to 7 mm (gray scale) and 3.6 cm (contours) continuum detected with the VLA. Araya *et al.* (2007b) concluded that the 3.6 cm emission is tracing an ionized jet whereas the 7 mm emission is dominated by dust emission from a possible massive circumstellar disk (torus). The H_2CO maser is coincident with the massive disk candidate.

Churchwell 2002), thus the H_2CO maser pinpoints a very young region of massive star formation. Olmi *et al.* (2003) report evidence of infall and a massive rotating disk in the hot molecular core. Thus, the H_2CO 6 cm emission may be associated with a disk around a massive young stellar object. However, the assumption of a single massive disk might be over-simplistic given the complex sub-mm morphology found by Beuther *et al.* (2007).

– **NGC 7538 IRS1** is a massive star forming region which harbors a hyper-compact H II region (e.g., Sewiło *et al.* 2004a), and a CO outflow centered at the NGC 7538 IRS1 position (Figure 2, right panel). NGC 7538 IRS1 is one of the few sources where a circumstellar disk around a massive (proto)star has been reported. However, the orientation of the disk is controversial. Based on CH_3OH maser data by Minier *et al.* (1998, 2000, 2001), Pestalozzi *et al.* (2004) report a possible Keplerian disk oriented ∼ SE–NW. However, based on mid-IR observations, De Buizer & Minier (2005) considered that the CH_3OH masers are tracing the outflow and that the disk is oriented in a NE–SW direction (i.e., perpendicular to the CO outflow, see Figure 2, right panel). As mentioned in §4, the two H_2CO maser spots are oriented NE–SW, and the velocity gradient of Comp. I is also in the NE–SW direction, i.e., perpendicular to the CO outflow and parallel to the MIR disk. The H_2CO 6 cm masers appear to trace material very close to (within 1000 AU) or directly associated with a circumstellar disk.

– **IRAS 18566+0408** was classified by Zhang (2005) as a massive circumstellar disk candidate. Based on high sensitivity and angular resolution 6, 3.6, 1.3, and 0.7 cm VLA continuum observations, Araya *et al.* (2007b) recently found supporting evidence for the presence of a massive circumstellar disk in IRAS 18566+0408 (see Figure 5). The massive disk (torus) is traced by 7 mm dust emission and has an elongation almost perpendicular to an ionized jet traced by cm radio continuum. The H_2CO maser is coincident with the center of the massive disk candidate.

7. The pumping mechanism of H_2CO 6 cm masers

Although the number of H_2CO 6 cm maser sources is still small, in the past few years significant progress in the characterization of H_2CO masers and their environments has been made; however, a theoretical understanding of the excitation mechanism of H_2CO masers is still lacking. Even before the detection of the first H_2CO maser, several authors mentioned and/or discussed possible excitation mechanisms that would result in maser emission of the 6 cm line; including collisional excitation with H_2 molecules and electrons (Thaddeus 1972; see also Fig. 14 of Evans *et al.* 1975a), and infrared pumping (Litvak 1970). However, only Boland & de Jong (1981) developed a specific model to explain one of the known H_2CO masers (NGC 7538). This model is based on inversion via background radio continuum radiation; however, the model appears to be incapable of explaining most of the known H_2CO masers (Araya *et al.* 2007b, Hoffman *et al.* 2007, 2003, Pratap *et al.* 1994, Mehringer *et al.* 1994; see however Pratap *et al.* 1992).

Besides inversion by radio continuum, other proposed excitation mechanisms appear to be possible: 1. Hoffman *et al.* (2007, 2003) and Araya *et al.* (2005) find indications that the masers could be collisionally excited in shocked regions (see also Martín-Pintado *et al.* 1999), 2. some H_2CO masers are found close to deeply embedded infrared objects and thus infrared pumping could be possible (Araya *et al.* 2006a), and 3. H_2CO masers are located close to very young massive stellar objects where a high ionization fraction is expected, and thus electron collision may play a role in the pumping.

Araya *et al.* (2007 *in prep.*) explore excitation of H_2CO masers via H_2 and electron collisions and have found that collision with electrons can indeed produce an inversion of the 6 cm K-doublet (see also Thaddeus 1972). However, preliminary results by Araya *et al.* (2007 *in prep.*) appear to require long path lengths ($\sim$ parsec scales) to reproduce the brightness temperature of the known H_2CO masers. Parsec-scale path lengths of coherent velocity and homogeneous physical conditions in massive star forming regions are unlikely. However pumping of H_2CO by electron collisions appears to be a promising mechanism to explain extragalactic megamasers (Araya *et al.* 2007 *in prep.*, see also Araya *et al.* 2004a; Baan & Haschick 1995). Araya *et al.* (2007 *in prep.*) also find that including radiation trapping, the 6 cm K-doublet may be inverted at a molecular density of $\sim 10^6$ cm^{-3} (i.e., in the transition between anomalous H_2CO absorption and thermalization). However, the model depends on accurate H_2(ortho/para) – H_2CO collision rates which are not available at present (e.g., Green 1991; see also Hoffman *et al.* 2003).

8. Why are H_2CO masers so rare?

In spite of a number of surveys specifically focused on the search for H_2CO masers and hundreds of sources for which H_2CO 6 cm absorption studies have been conducted (e.g., Table 1, Araya *et al.* 2002, Watson *et al.* 2003, Sewiło *et al.* 2004), H_2CO maser emission has been detected only toward seven regions (and in a total of 15 maser spots at $1''$ resolution). Thus, H_2CO maser emission is indeed a rare phenomenon. Reformulating the ideas presented by Mehringer *et al.* (1995), Pratap *et al.* (1992), and Forster *et al.* (1985), H_2CO masers may be uncommon because: 1. they are weak in comparison with other astrophysical masers and/or are highly beamed: the brightest known H_2CO maser is just $\sim$ 2 Jy; 2. they occur at LSR velocities close to the systemic velocity of the star forming regions and thus the maser emission is highly attenuated by large optical depths of the H_2CO absorption line: H_2CO masers are typically found within ~ 5 km s^{-1} from the systemic cloud velocity as traced by H_2CO absorption (e.g., Figure 2, Araya *et al.* 2004b) and are not found at high velocities, indicating that H_2CO masers are not associated with high velocity outflows; and 3. the physical conditions needed for the excitation of the masers are very specific, and thus, short-lived in massive star forming region environments. For example, the H_2CO masers (and H II regions) in Sgr B2 are distributed in a N–S direction suggesting that star formation in Sgr B2 was triggered by a cloud collision event (see Sato *et al.* 2000) and thus the masers may be tracing an isochrone of the physical conditions during the massive star formation process (see Gardner *et al.* 1986).

9. Summary

Despite the ubiquitous presence of H_2CO 6 cm absorption, there are only seven known H_2CO maser regions in the Galaxy. Recent VLBA and MERLIN observations toward four sources show brightness temperatures between $10^5 - 10^9$ K, and physical sizes between 30–200 AU. At least two masers show long-term variability (>1 year), and one maser source was recently shown to exhibit recurrent short-term (< 3 months) bursts. All known H_2CO 6 cm masers are found in massive star forming regions, and in the case of the three sources that have been studied in detail (NGC 7538 IRS1, G29.96−0.02, and IRAS 18566+0408; excluding Sgr B2) the H_2CO masers pinpoint the location of candidate disks around massive protostars. However, the H_2CO maser mechanism has to be clarified before the masers can be used as an astrophysical probe.

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