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# EXPANDED VLA DETECTION OF 36.2 GHZ CLASS I METHANOL MASERS IN SAGITTARIUS A

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## ABSTRACT

We report on the interferometric detection of 36.2 GHz Class I methanol emission with the new 27–40 GHz Ka band receivers available on the Expanded Very Large Array (EVLA). The brightness temperatures of the interferometric 36 GHz detections unambiguously indicate for the first time that the emission is maser emission. The 36 GHz methanol masers are not co-spatial with 1720 MHz OH masers, indicating that the two species trace different shocks. The 36 GHz and 44 GHz methanol masers, which both are collisionally pumped, do not necessarily co-exist and may trace different methanol gas. The methanol masers seem correlated with $NH_3$(3,3) density peaks. We favor an explanation in which the 36 GHz Class I methanol masers outline regions of cloud-cloud collisions, perhaps just before the onset of the formation of individual massive stars.

The transition of the Very Large Array (VLA) to the EVLA is well under way, and these detections demonstrate the bright future of this completely renewed instrument.

*Subject headings:* masers — ISM: clouds — ISM: individual objects (Sgr A) — ISM: supernova remnants — Galaxy: center — radio lines: ISM

## 1. INTRODUCTION

Methanol ($CH_3OH$) masers are typically classified as Class I and Class II methanol masers. The Class II methanol masers may be pumped by strong far infrared radiation and are related to star forming regions. Class I methanol masers are probably pumped by collisions and are found in regions where outflows or clouds collide. This distinction is based on observations using sufficient angular resolution, where Class II masers are found to be co-spatial ($\sim 1''$) with ultracompact HII regions whereas Class I masers are near (few arcseconds), but not co-spatial with HII regions (e.g., Menten 1991; Liechti & Wilson 1996).

Bright 36 GHz methanol emission has been found in many regions such as the Galactic center source Sgr A, Sgr B2, OMC1 and 2, and other Galactic star forming regions. It is usually found in sources with other Class I masers, such as the 44 and 95 GHz lines (e.g., Haschick et al. 1990; Menten 1991; Müller et al. 2004; Fish 2007). Due to the fact that all previous observations at 36 GHz have been taken with single-dish telescopes, it has heretofore not been unambiguously established that the 36 GHz methanol emission is due to maser action (Menten 1991; Pratap et al. 2008)

In Sgr A, the brightest 36 GHz line emission is found in the northeastern part of the Sgr A East supernova remnant (SNR), located near the region where the SNR interacts with the M–0.02–0.07 molecular cloud (intensity $\gg$ 1 Jy beam$^{-1}$ using a single dish, e.g., Morimoto et al. 1985; Haschick & Baan 1989; Szczepanski et al. 1989; Haschick et al. 1989; Liechti & Wilson 1996). Recently, Sjouwerman & Pihlström (2008) detected several 1720 MHz OH masers in the same region (Fig. 1). These OH masers are collisionally pumped and are considered typical signposts of shock excited material. Theoretical modeling indicates a similar range of physical properties ($T_K \sim$ 80-100 K, $n \sim 10^4$-$10^5$ cm$^{-3}$) for 36 GHz Class I methanol and 1720 MHz OH maser excitation (Morimoto et al. 1985; Pratap et al. 2008; Pihlström et al. 2008; Menten et al. 2009). That is, if there is methanol abundance near a 1720 MHz OH maser, there may be 36 GHz Class I methanol masers. This is supported by the fact that locations of the northeastern 1720 MHz OH masers in Sgr A are consistent with the core of the 36 GHz methanol emission.

The new 27–40 GHz (Ka band) receivers recently commissioned on the (Expanded) Very Large Array (EVLA/VLA, Ulvestad et al. 2006) enable interferometric high angular resolution observations of sources hosting 36 GHz masers. Here we report on the first interferometric observation of the Sgr A region in the 36 GHz line of methanol with the EVLA to investigate whether this emission may be due to maser activity and, if so, whether it is co-spatial with the shock-excited 1720 MHz OH masers. We report on initial results confirming the maser nature of the 36 GHz methanol emission and identifying their location relative to the 1720 MHz OH masers. A future paper will provide a more complete analysis of our observations.

## 2. OBSERVATIONS

The VLA was used at 36 GHz ($\lambda$ = 8.3 mm) in 2009 March and April, after 9 EVLA type Ka band receivers were deployed. The receivers were placed within the B array configuration to optimize the sampling in the *(u,v)*-plane, with the longest baseline measuring $\sim$7.5 km (870 k$\lambda$). This "limited B array" used baselines of 70 k$\lambda$ and up and resulted in a synthesized beam of about 200-400 mas in a primary beam (field of view) of about 68$''$ diameter. However, in March only 7 antennas yielded usable data. Because the new receivers have a new frequency tuning system, a new observation preparation tool (OPT) was used. This new OPT software is a web based application that will completely replace the tools currently used to prepare observations for the VLA ("Jobserve").

The VLA correlator was configured to deliver Doppler tracked data at 3.3 second integration intervals for a single dual polarization IF pair using 6.25 MHz total band-

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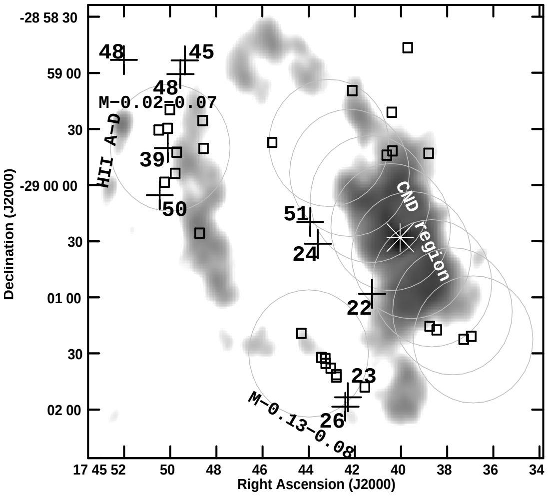


**Figure 1.** Gray scale outline of Sgr A in 1.7 GHz radio continuum with 1720 MHz OH masers (squares; see also Sjouwerman & Pihlström 2008). The newly detected 36 GHz methanol masers are located at the plus-signs and labeled with their LSR velocities. The closest angular separation between any methanol and OH maser is 6.5″ (0.25 parsec). Sgr A* is located in the dark CND region to the west (white star). The large gray circles show the 68″ diameter primary beams; the core of M−0.02−0.07 is covered by the easternmost beam.

width (∼50 km s$^{-1}$). This bandwidth was divided in 63 channels at 0.8 km s$^{-1}$ (97.7 kHz) separation and tuned to the $J = 4_{-1} \rightarrow 3_0 E$ rotational transition of methanol at 36 169.265 MHz (Müller et al. 2004). The amplitude scale was adopted using the standard spectrum of 3C286 (Baars et al. 1977); pointing, bandpass and complex gain calibration was performed using NRAO530 and Sgr A*.

In March, 8 different position/velocity settings covered the circumnuclear disk (CND) around Sgr A* over two arcminutes and ±150 km s$^{-1}$ in the reference frame of the Local Standard of Rest (LSR). Each was observed for ∼15 minutes. Additionally, ∼3 minute on source pointings were included on two regions where many 1720 MHz OH masers are located. One of them pointed at the core of M−0.02−0.07 toward the east (Fig. 1). In April selected fields were reobserved with 3–4 minute on source integration times and with shifted Doppler velocity settings to confirm potential detections from the first run.

## 3. RESULTS

Table 1 and Figs. 1 and 2 summarize our results for selected 36 GHz methanol masers (Sect. 4.1). These masers are all redetected in our different observations and are either the brightest members of clusters of masers found near the northeastern 1720 MHz OH masers or individual (weaker) masers near the southeastern 1720 MHz OH masers and the CND. Our complete list of tens of detections will be given in a later manuscript.

The data reduction, performed with the AIPS package, was complicated by the strong methanol lines that were present in all pointings except for the highest absolute velocities (at $|V_{LSR}| > 80$ km s$^{-1}$). We produced image cubes that were cleaned well beyond (2.5 times) the primary beam, since significant emission was detected beyond the primary beam in several pointings (Fig. 1). We derived approximate flux densities of 1.7, 3.6(±0.1) and 1.1(±0.1) Jy for our calibrator sources 3C286, NRAO530 and Sgr A*, respectively. Typical values for the RMS image noise in a line-free channel were 10–12 mJy beam$^{-1}$.

**Table 1**
Results on selected detections

| | Right Ascension & Declination (J2000) | | $V_{LSR}$ (km s$^{-1}$) | ΔV | Flux † | $T_B$ (K) |
|---|---|---|---|---|---|---|
| 1 | 17 45 41.25 | −29 00 58.1 | +21.5 | 1.6 | 0.95 | $> 1.1 \cdot 10^4$ |
| 2 | 17 45 42.30 | −29 01 53.4 | +23.1 | 0.8 | 0.67 | $> 1.4 \cdot 10^4$ |
| 3 | 17 45 42.41 | −29 01 58.5 | +25.6 | 1.6 | 0.76 | $> 9.7 \cdot 10^3$ |
| 4 | 17 45 43.60 | −29 00 31.4 | +24.0 | 1.6 | 3.86 | $> 6.7 \cdot 10^4$ |
| 5 | 17 45 43.93 | −29 00 19.7 | +50.7 | 1.6 | 0.52 | $> 9.1 \cdot 10^3$ |
| 6* | 17 45 49.36 | −28 58 53.3 | +45.0 | 7.3 | 154 | $> 8.8 \cdot 10^5$ |
| 7* | 17 45 49.55 | −28 59 00.6 | +48.2 | 5.7 | 62.4 | $> 4.6 \cdot 10^5$ |
| 8* | 17 45 50.10 | −28 59 40.2 | +39.3 | 4.9 | 215 | $> 2.3 \cdot 10^6$ |
| 9* | 17 45 50.45 | −29 00 05.4 | +49.9 | 3.2 | 60.4 | $> 6.8 \cdot 10^5$ |
| 10* | 17 45 52.00 | −28 58 53.1 | +48.2 | 1.6 | 35.1 | $> 6.1 \cdot 10^5$ |

†: Line flux in Jy·km s$^{-1}$
*: Brightest component of a cluster of detections

Table 1 lists selected maser detections with the position and velocity of the channel of peak emission, the span of velocities over which emission was detected, the integrated line flux, and a lower limit of the brightness temperature (derived from the flux density at the line peak). The masers on the eastern side of Sgr A were self-calibrated. The masers near the CND are outside our primary beam and self-calibrated using Sgr A*. But because we have confirmed their positions within 0.3″, based on redetections of these masers in the April data, we can be confident that the positions are accurate enough to place the masers among the other phenomena in the Sgr A region, such as the 1720 MHz OH masers in Fig. 1 and the HCN and $NH_3$(3,3) emission in Fig. 2.

An absolute flux scale for Ka band has not yet been formalized, but the flux density measured for Sgr A* (1.1 Jy) is consistent with the expected flux at this wavelength, thus lending confidence in our flux scale. We have modified our fluxes in Table 1 for the yet-undetermined primary beam attenuation of the EVLA antennas at Ka band using a simple Gaussian beam pattern with the same FWHM as our primary beam.

## 4. DISCUSSION

### 4.1. *Some 36 GHz Methanol Emission is* Maser *Emission*

Until recently, 36 GHz methanol emission was solely observed with single dish instruments, with typical spectra showing narrow peaked emission, sometimes strong, on top of a broader wide base (e.g. Morimoto et al. 1985; Haschick & Baan 1989; Szczepanski et al. 1989, 1991; Liechti & Wilson 1996). Because of the limited angular resolution, 36 GHz methanol modeling has not been heavily pursued (however see, e.g., Morimoto et al. 1985; Cragg et al. 1992; Liechti & Wilson 1996; Menten et al. 2009, for individual modeling of the 36 GHz methanol line). Most authors have convincingly argued that the spectra indicate a broad thermal emission component with strong, narrow maser emission components superimposed. Due to the large beam sizes of the single dish telescopes used, the lower limits these authors have placed on the brightness temperatures of these narrow components has not been high enough to prove unambiguously that the emission mechanism is maser, not thermal. Liechti & Wilson (1996) present a nice discussion, including a counter example (their Sect. 4.1). The interferometric point-like detection of the 36 GHz methanol emission in this work, utilizing a much smaller synthesized beam size than with the single dish observations previously, has clearly put lower limits on the brightness temperature of several masers above $10^5$ K (Table 1). That is, the 36 GHz methanol emission must be *maser* emission, as suspected by previous authors.

### 4.2. *1720 MHz OH versus 36 GHz Methanol Maser Emission*

Both (36 GHz) Class I methanol and 1720 MHz OH maser emission is generally considered to be tracing shock interaction regions. Szczepanski et al. (1989, 1991) and Liechti & Wilson (1996) have published mosaics of 36 GHz methanol emission in the Sgr A region using the single dishes of Haystack and Effelsberg (with 40″ and 25″ angular resolution, respectively), consistent with each other and this work. The direction of the CND was only covered by Szczepanski et al. (1991), although they did not use a bandwidth wide enough to observe the full range of LSR velocities ($\pm150$ km s$^{-1}$) present in the CND. Their methanol results are consistent with the parsec scale location and kinematics of the cores of the giant molecular clouds M–0.02–0.07 and M–0.13–0.08 (also known as the +50 km s$^{-1}$ and +20 km s$^{-1}$ clouds respectively; Zylka et al. 1990) as determined in many other molecular lines and infrared dust emission. The broad line profile of the methanol emission was suggested to originate from material shocked and compressed by the impact of nearby SNRs (Sgr A-East and G359.02–0.09 respectively), whereas the narrow profiles were postulated to be due to maser emission (Sect. 4.1). The location of shock excited 1720 MHz OH masers is also consistent with this picture (Sjouwerman & Pihlström 2008). That is, the OH masers and methanol emission both originate in the molecular material that is being shocked by the expansion of SNR material.

We detect tens of 36 GHz methanol masers toward the core of M–0.02–0.07, of which the brightest in each cluster of detections are shown in Table 1 and Fig. 1. The very brightest maser ($\gg 100$ Jy) was probably previously detected as the "spike" of emission in the "Grid C" spectrum of Szczepanski et al. (1989). The methanol maser positions are well separated ($\sim$ 15–30″, 0.5–1.2 parsec) from, and to the west of the HII regions A–D. They are placed amongst the 1720 MHz masers (Fig. 1) with velocities consistent with the molecular cloud. This location, away from A–D toward the west, is also consistent with the location of the "Grid C" spectrum of Szczepanski et al. (1989, their Fig. 2). We did not detect a thermal component of the molecular cloud with the long baselines used, but the masers themselves do not explain all emission seen by Szczepanski et al. (1989, 1991) and Liechti & Wilson (1996). We deduce that the *thermal* emission detected by the single dish observations is consistent with originating in the molecular cloud core and the *maser* emission is consistent with an origin in the cloud core or west of the cloud core near the interaction region with the SNR expansion.

The velocities of the methanol and OH masers in the northeastern part of Sgr A differ by 5–30 km s$^{-1}$, with the methanol velocities most compatible with the kinematics of the core. This suggests that the methanol masers are more closely related to the cloud core whereas the OH masers are likely outlining post-shock gas from the interaction of the SNR with the molecular cloud. We note the striking alignment of methanol masers with the northeastern part of the continuum rim of the SNR, where the northeastern 1720 MHz OH masers are more scattered. We also note the striking alignment of three methanol masers with the outer contours of the HCN emission of the CND (see Sect. 4.4), and the alignment of methanol masers with the southeastern OH masers. However, as the minimum angular separation between a methanol-OH maser pair in any of our detections is 6.5″ (0.25 parsec), we can conclude that 1720 MHz OH and 36 GHz methanol masers are not co-spatial (within $\sim 1''$). The general difference in velocity between OH and methanol masers suggests that they trace different shocks, or different gaseous components of a shocked region if both maser transitions are due to a shared origin. Perhaps this indicates that the methanol is located deeper in the cloud, where the line-of-sight LSR velocity is not as much disturbed by the SNR shock front as the region where the OH masers originate, and perhaps requiring less energetic shock excitation than OH. The location and physical properties of the gas giving rise to the 36 GHz methanol masers (T $<$ 100 K and $n \sim 10^4 - 10^5$ cm$^{-3}$: Morimoto et al. 1985; Cragg et al. 1992; Liechti & Wilson 1996; Menten et al. 2009) also somewhat differ from the gas traced by 1720 MHz masers (T $\sim$ 75 K and $n \sim 10^5$ cm$^{-3}$: Pihlström et al. 2008).

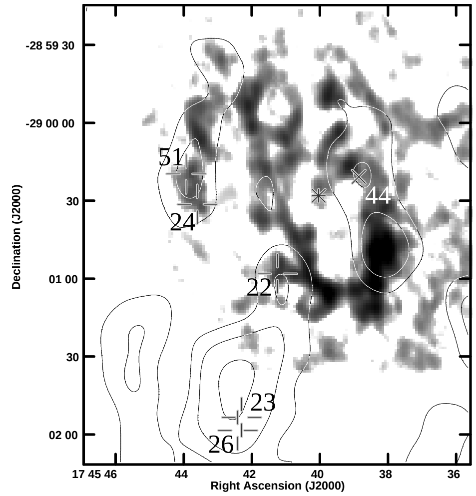


**Figure 2.** Integrated intensity contours of $NH_3$(3,3) emission and integrated intensity gray scale of HCN(4-3) emission outlining the ring-like CND (see also McGary et al. 2001; Montero-Castaño et al. 2009). The newly detected 36 GHz methanol masers near the CND (plus-signs) are labeled with their LSR velocities, as is the 44 GHz methanol maser "V" (cross) (Yusef-Zadeh et al. 2008). The star locates Sgr A* for reference. The HCN(4-3) image only partly covers the frame.

We note that no bright 36 GHz masers were detected in the tangent points of the CND, at $V_{LSR} \sim \pm130$ km s$^{-1}$, where 1720 MHz OH masers indicate that energetic shocks are present. Perhaps these regions are too warm, too dense, or devoid of methanol. Alternatively, these shocks may be too strong for 36 GHz methanol masers to exist.

### 4.3. *Molecular clumps and Methanol Maser Emission*

Three 36 GHz methanol masers were detected near and (south)east of the CND (Figs. 1 and 2). These masers are located just beyond the primary beam, but can be observed in the field of our phase calibrator (Sgr A*) as well as in two other observed fields. With the single dish Green Bank telescope ($\sim$ 15″ angular resolution), Yusef-Zadeh et al. (2008) place two bright 44 GHz Class I methanol masers in the same region (see Sect. 4.4), located westward and consistent with the velocity of the HCN(1-0) "clumps" "F" and "G" (Christopher et al. 2005), which are the HCN(4-3) "clumps" "CC" and "BB" (Montero-Castaño et al.

2009). Two of the 36 GHz masers are located near clump "G"/"BB" and another is located eastward of HCN(1-0) clump "J"/"K" (Christopher et al. 2005), in HCN(4-3) clump "X" (Montero-Castaño et al. 2009). They all have a velocity distinct from nearby HCN emission in the CND, although HCN emission is present at the maser velocities ($\sim 50-55$ and $\sim 20-25$ km s$^{-1}$; Montero-Castaño et al. 2009, their Figs. 4 and 7). It is therefore likely that the methanol masers and the HCN clumps, located eastward and with a velocity deviating from the CND, are related.

It is even more interesting to note that the three methanol masers near the CND, as well as the two detections toward the south of the CND and the masers near the core of M–0.02–0.07, all appear to be located in $NH_3$(3,3) density clumps (McGary et al. 2001, Fig. 2). Observations of ammonia in the Sgr A region have revealed finger-like protrusions of gas toward the CND (e.g., Coil & Ho 2000; McGary et al. 2001), suggesting the existence of streamers and/or gas extensions from the cores of M–0.02–0.07 (westward) and M–0.13–0.08 (northward) in the direction of, and possibly feeding, the CND. This gas could have been "loosened" by the SNR impacting in the clouds. The three 36 GHz methanol masers near the CND at the HCN clumps "G"/"BB" and "X" exactly lie on top of $NH_3$(3,3) emission peaks which supposedly outline where gas is impacting into the outer regions of the CND (e.g., McGary et al. 2001).

### 4.4. *Class I 44 GHz and 36 GHz Methanol Maser Emission*

Yusef-Zadeh et al. (2008) detected 44 GHz methanol maser emission in five regions toward Sgr A with the single dish Green Bank telescope with an angular resolution of about 15″. These authors confirmed two detections with the VLA, but do not detail the interferometric data[1]. The single dish observations attributed two of their masers to the HII regions "A" and "D". We believe their physical association with the HII regions is unlikely, due both to the sparse angular resolution of their observations and the fact that the HII regions are are in the foreground (e.g. Karlsson et al. 2003). With our new data, it seems likely that these two 44 GHz masers are closely related to 36 GHz masers found in this region.

Two 44 GHz masers, placed directly east of the CND by Yusef-Zadeh et al. (2008), are near two 36 GHz masers detected in this work. The northern most of these 44 GHz masers is positioned near a water maser and may indicate an early stage of massive star formation or, alternatively, be due to an evolved star (Yusef-Zadeh et al. 2008). However, within their positional accuracy it is possible that the brightest emission in this beam could arise from the brighter southern 44 GHz maser at the same velocity (Yusef-Zadeh et al. 2008, see their Fig. 1). This bright feature was not confirmed in their VLA observations. The southern 44 GHz maser has a position and velocity consistent with the 36 GHz maser at $V_{LSR}$ = 51 km s$^{-1}$. We determine the angular separation between the 36 and 44 GHz masers to be about 2″ using their Fig. 4.

No bright 44 GHz masers appear to have been detected at the velocity of the other two 36 GHz masers at $V_{LSR}$ = 22 and 24 km s$^{-1}$. In addition, no 36 GHz emission is detected near the position of the weakest 44 GHz maser, northwest of Sgr A* (at $V_{LSR} \sim 44$ km s$^{-1}$ near HCN "V" or "H"; Christopher et al. 2005; Montero-Castaño et al. 2009; Yusef-Zadeh et al. 2008). This 44 GHz maser, like all 36 GHz and probably all other 44 GHz masers, is also located in a $NH_3$(3,3) density clump (McGary et al. 2001, Fig. 2).

We thus find 36 GHz masers probably co-spatial with 44 GHz masers as well as isolated 36 GHz and isolated 44 GHz masers. Whether observations of any combination of these masers (e.g. Pratap et al. 2008) is direct evidence for star formation or whether these Class I masers indicate different temperatures and densities in shocked gas can now be investigated at high angular resolution. Yusef-Zadeh et al. (2008) suggest that the 44 GHz masers near the CND indicate the onset of massive star formation, but our complementary 36 GHz data suggest that the picture might be less clear. The Class I methanol masers and the suggestions of gas feeding the CND from the molecular cloud cores (e.g., Szczepanski et al. 1991; Coil & Ho 2000, and references therein) may perhaps better be explained by cloud-cloud interactions creating shock waves at those locations. Perhaps an arcsecond angular resolution interferometric survey of 36 GHz (and 44 GHz) methanol in the whole Sgr A region and a VLBI proper motion study of these masers will enlighten this issue.

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*Facilities:* EVLA (), VLA ()

## REFERENCES

Baars, J. W. M., Genzel, R., Pauliny-Toth, I. I. K., & Witzel, A. 1977, A&A, 61, 99
Christopher, M. H., Scoville, N. Z., Stolovy, S. R., & Yun, M. S. 2005, ApJ, 622, 346
Coil, A. L., & Ho, P. T. P. 2000, ApJ, 533, 245
Cragg, D. M., Johns, K. P., Godfrey, P. D., & Brown, R. D. 1992, MNRAS, 259, 203
Fish, V. L. 2007, IAU Symposium, 242, 71
Haschick, A. D., & Baan, W. A. 1989, ApJ, 339, 949
Haschick, A. D., Baan, W. A., & Menten, K. M. 1989, ApJ, 346, 330
Haschick, A. D., Menten, K. M., & Baan, W. A. 1990, ApJ, 354, 556
Herrnstein, R. M., & Ho, P. T. P. 2002, ApJ, 579, L83
Karlsson, R., Sjouwerman, L. O., Sandqvist, A., & Whiteoak, J. B. 2003, A&A, 403, 1011
Liechti, S., & Wilson, T. L. 1996, A&A, 314, 615
McGary, R. S., Coil, A. L., & Ho, P. T. P. 2001, ApJ, 559, 326
Menten, K. M. 1991, ApJ, 380, L75
Menten, K. M., Wilson, R. W., Leurini, S., & Schilke, P. 2009, ApJ, 692, 47
Montero-Castaño, M., Herrnstein, R. M., & Ho, P. T. P. 2009, ApJ, 695, 1477
Morimoto, M., Kanzawa, T., & Ohishi, M. 1985, ApJ, 288, L11
Müller, H. S. P., Menten, K. M., Mäder, H. 2004, A&A, 428, 1019
Pihlström, Y. M., Fish, V. L., Sjouwerman, L. O., Zschaechner, L. K., Lockett, P. B., & Elitzur, M. 2008, ApJ, 676, 371
Pratap, P., Shute, P. A., Keane, T. C., Battersby, C., & Sterling, S. 2008, AJ, 135, 1718
Sjouwerman, L. O., & Pihlström, Y. M. 2008, ApJ, 681, 1287
Szczepanski, J. C., Ho, P. T. P., Haschick, A. D., & Baan, W. A. 1989, The Center of the Galaxy, 136, 383
Szczepanski, J. C., Ho, P. T. P., & Güsten, R. 1991, Atoms, Ions and Molecules: New Results in Spectral Line Astrophysics, 16, 143
Ulvestad, J. S., Perley, R. A., McKinnon, M. M., Owen, F. N., Dewdney, P. E., & Rodriguez, L. F. 2006, Bulletin of the American Astronomical Society, 38, 135
Yusef-Zadeh, F., Braatz, J., Wardle, M., & Roberts, D. 2008, ApJ, 683, L147
Zylka, R., Mezger, P. G., & Wink, J. E. 1990, A&A, 234, 133

[1] The VLA observations date from after their Letter was first submitted.