1. INTRODUCTION

The nature of Galactic formaldehyde (H₂CO) masers is a growing mystery. While hundreds of Galactic OH, H₂O, and CH₃OH masers are known, only five Galactic star-forming regions have associated H₂CO maser emission. To date, this emission is seen only in the 1₁₀ ← 1₁₁ transition at 6 cm wavelength. Shortly after the discovery of the first H₂CO maser in NGC 7538 (Downes & Wilson 1974; Forster et al. 1980), a radiative pumping model was proposed (Boland & de Jong 1981). The H₂CO masers discovered subsequently did not meet the conditions required for this mechanism (Gardner et al. 1986; Mehringer et al. 1994, hereafter MGP94; Hoffman et al. 2003, hereafter H03). Thus, 25 years after the discovery of the first H₂CO maser, these sources remain rare, and the excitation mechanism remains unknown.

Sgr B2, the northernmost component of the extended Sgr B radio source, is located within a few hundred parsecs of the Galactic center (Reid et al. 1988). The distance to the Galactic center is assumed to be 8.5 kpc in this paper.) Sgr B2 is comprised of three main star-forming complexes designated north (N), middle or main (M), and south (S), and many smaller H ii regions. The H₂CO masers occur throughout Sgr B2, shown in Figure 1. The heating mechanisms and complex chemistry of the region are subjects of ongoing study (e.g., Gaume & Claussen 1990; Goicoechea et al. 2004).

Sgr B2 contains nine individual H₂CO maser regions, several of which have multiple velocity components. All of the masers are unresolved at 1″ angular resolution, except for maser C, which MGP94 suggested consists of several masers blended within the beam. These regions are near H ii regions distributed over the ~3.6 arcmin² complex (MGP94). Whiteoak & Gardner (1983) and MGP94 designated the maser regions with letters (Fig. 1). The H₂CO masers are observed over the velocity range +40 km s⁻¹ ≤ v_LSR ≤ +80 km s⁻¹, while other species, such as H₂O masers, are observed over a larger range −30 km s⁻¹ ≤ v_LSR ≤ +120 km s⁻¹ (Kobayashi et al. 1989; McGrath et al. 2004). Of the nine maser regions observed in Sgr B2 by MGP94, the G maser was shown to be time variable, at least quadrupling in intensity over 10 yr. Similarly, H03 found one NGC 7538 feature to triple in intensity over ≈10 yr.) As initially noted by Whiteoak & Gardner (1983), all of the Sgr B2 H₂CO masers lie close to OH, H₂O, CH₃OH, and NH₃ masers. For most of the masers in MGP94, the separation to an OH maser was less than 0.05 pc.

Recent successes in search techniques for new masers (Araya et al. 2004, 2005, 2006) and in high-resolution observational techniques (H03) promise to provide empirical constraints for the development of a realistic model for the Galactic H₂CO maser emission. The necessary steps in compiling an empirical picture of the H₂CO emission in Sgr B2 are (1) detailed imaging of the masers in order to quantify the intrinsic properties of the emission (e.g., brightness temperature); (2) assessment of intensity variability in the masers; and (3) precise astrometry for elucidating spatial relationships between the H₂CO masers and more common masers (OH, H₂O, and CH₃OH). In this paper, we present new observations of the H₂CO masers in Sgr B2 using the Very Long Baseline Array (VLBA) and Very Large Array (VLA) of the NRAO.¹

2. OBSERVATIONS AND RESULTS

2.1. VLBA+Y27

We observed the A and D H₂CO masers in Sgr B2 using the 10 antennas of the VLBA and the 27 antennas of the VLA as an 11-station very long baseline interferometry (VLBI) array.

¹ The VLBA and VLA are components of the National Radio Astronomy Observatory (NRAO), which is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.
Parameters of the observations are summarized in Table 1. The total observing time was approximately 8.0 hr, alternating between the A and D pointing positions, which are separated by approximately 1'. At each pointing position there is a useful correlated field of view of approximately 1'' (e.g., Bridle & Schwab 1999). To observe each of the nine H$_2$CO masers in Sgr B2 optimally would have required observations at nine pointing centers. Because of signal-to-noise ratio considerations, we observed only the two masers measured to be most intense by MGP94. The baseline lengths of the VLBA+Y27 array range from 52 to 8611 km; the array is not sensitive to angular scales larger than 0.25''.

The maser observations were phase referenced to J1745+283 (called W56 in Bower et al. 2001). Because the properties of this source limit our observations, we discuss it in some detail. The absolute position uncertainty of this source is 12 mas (Reid et al. 1999). Bower et al. found that J1745+283 is probably the core of an extragalactic jet source and that its apparent size at 5 GHz (30 mas) is determined by scatter broadening. We also observed polarized feeds from which RR, LL, RL, and LR cross-correlations were formed. The visibilities were integrated for 8.4 s. The amplitude scale is set using online system temperature monitoring and a priori antenna gain measurements. The station delays were determined from observations of J1733−130.

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| Instrument          | VLBA+Y27                                                                 | VLA                                                                 |
|---------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------|
| Observing date(s)   | 2003 May 17 and 22                                                      | 2005 October 11, 13, and 14                                           |
| Position (J2000.0)  | 17 47 20.0463, −28 23 46.587                                           | 17 47 19.96, −28 22 59.8                                             |
|                     | 17 47 19.8562, −28 22 12.900                                           |                                                                     |
| Synthesized beam    | (A) 20 × 15 mas, P.A.= 1°                                              | 10.7″ × 9.0″, P.A.= 88°                                              |
|                     | (D) 35 × 21 mas, P.A.= 1°                                              |                                                                     |
| Flux density calibrator | J1745–283                                                               | 3C 286                                                               |
| Phase calibrator    | J1733–130                                                               |                                                                     |
| Bandpass calibrator | J1751–253                                                               |                                                                     |
| Rest frequency      | 4829.6569 MHz                                                           | 4829.6590 MHz                                                        |
| Number channels     | 128                                                                     | 63                                                                   |
| Channel spacing     | 1.953 kHz                                                               | 3.052 kHz                                                            |
| Velocity resolution | 0.24 km s⁻¹                                                              | 0.19 km s⁻¹                                                          |
| Center velocity     | 50.6 and 75.6 km s⁻¹                                                    | 51.4 and 74.6 km s⁻¹                                                 |
| Total velocity range| ±7.5 km s⁻¹                                                              | ±5.5 km s⁻¹                                                          |
| Typical noise per channel | 35 mJy beam⁻¹                                                       | 5 mJy beam⁻¹                                                         |

**Note.**—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.

* After Hanning smoothing.

Fig. 2.—VLBA+Y27 image of the H₂CO A maser at $v_{LSR} = 75.4$ km s⁻¹. The contour levels are −4, 4, 8, 12, and 16 times the image rms noise level of 40 mJy beam⁻¹ (no negative contours appear). The beam (lower left corner) is 26 × 9 mas at a position angle of 4°. The gray scale at the top is in units of mJy beam⁻¹. Inset: Spectrum at the A maser image peak. The observed properties are summarized in Table 2. The brightness temperature of the emission is $5.9 \times 10^8$ K.
J1745−283 on 2002 November 22 using only the 10 VLBA stations (a snapshot observation with a bandwidth of 4 MHz in both polarizations). The 2002 observation yields a deconvolved angular size of 21 × 18 mas and an integrated flux density of 28 mJy; the 2003 observation yields a size of 28 × 16 mas and a flux density of 31 mJy. (The flux density determined by Y27 [the VLBA alone] during the 2003 observations was 161 mJy.) Bower et al. reported an angular size 42 × 25 mas and peak intensity 89 mJy beam−1 from VLBA+Y1 observations. Therefore, the flux density must have decreased significantly between 1999 and 2002. Such variability would not be unusual for an inverted spectrum source such as J1745−283 (e.g., Urry & Padovani 1995).

Our imaging of J1745−283 with the VLBA makes use of only the innermost stations (VLA, Pie Town, Los Alamos, Fort Davis, Kitt Peak, and Owens Valley) because the source is resolved on longer baselines. Some additional resolution for the maser observations was gained by self-calibration; but because only the shorter baselines in the VLBA data were absolutely calibrated in phase, the position registration accuracy of the resulting VLBA images is approximately 15 mas. In summary, we could not make use of the full potential resolution of the VLBA when using this phase referencing calibrator, and no other suitable nearby source is known.

We detected masers toward the A and D regions. The F maser is also within the correlated field of view near the A maser, but was not detected with the current sensitivity. The image and spectrum of the A maser from the VLBI data are shown in Figure 2. Because the radio continuum of Sgr B2 is fully resolved by the VLBA, no continuum subtraction was necessary. The positions, center velocities (vLSR), line widths (ΔvFWHM), peak flux densities (S0), and deconvolved major and minor axes and position angles are summarized in Table 2. In parentheses following each entry are the 1σ errors.

The deconvolved sizes of the VLBI images of the A and D masers are ∼10 mas. At the distance of Sgr B2, this size corresponds to a linear diameter of approximately 80 AU, comparable to the sizes (30–130 AU) observed for the H2CO masers in NGC 7538 and G29.96−0.02 using the VLBA (H03). The brightness temperatures of the Sgr B2 A and D masers in the current VLBI data are 5.9 × 10^8 and 1.2 × 10^8 K, respectively, similar to the 10^7−10^8 K observed for other H2CO masers (H03). No significant linear or circular polarization is detected in either maser (≤20% for the strongest maser [A]).

### 2.2. VLA

Because of the known variability of H2CO masers (Forster et al. 1985; H03), the Sgr B2 masers were observed in 2005 with the VLA in order to access any possible time variability. Parameters of the observations are summarized in Table 1. The array configuration available was DrC for an observation period of approximately 7 hr. Two pairs of RR and LL bands were recorded centered at the expected velocities of the A and the D masers.

Of the nine maser regions described by MGP94, eight of the sources were detected. Six velocity components in the regions observed by MGP94 lie outside the velocity range of the current observations. No new H2CO maser regions were discovered.

The 2005 data have inferior angular resolution (10^−2 vs. 10^−3) but improved spectral resolution (0.19 vs. 1.5 km s^−1) compared with the 1993 VLA observations of MGP94. Comparison of the current data to the MGP94 data is uncertain due to (1) the severe blending of the strong H2CO absorption with the nearby masers and (2) the insufficient velocity resolution of the MGP94 data, which did not spectrally resolve the lines. Variability of the flux density of the masers is apparent and is discussed in § 3.2. The 2005 results are summarized in Table 3, and a spectrum from these data (region E) is shown in Figure 3. The C maser region is not discussed in this paper due to confusion of the maser spectra with nearby absorption and continuum emission. With the current 10^−3 resolution of the VLBA data, as with the 10^−2 resolution of MGP94, none of the masers are spatially resolved.

In § 3.2 we also compare the current data with the 1983 VLA observations of Gardner et al. (1986). The velocity resolution of the 1983 data is 0.76 km s^−1, and the angular resolution is 1.25″. Although we resolve many of the maser line profiles in velocity for the first time with the 2005 VLA data, most of the line widths presented in Table 3 agree with the values measured by Gardner et al. (1986).

### TABLE 2

| Source | α (J2000.0) | δ (J2000.0) | vLSR (km s^−1) | ΔvFWHM (km s^−1) | S0 (mJy beam^−1) | θa (mas) | θb (mas) | P.A. (deg) |
|--------|--------------|-------------|----------------|------------------|------------------|-----------|-----------|------------|
| A....... | 17 47 19.856(1) | −28 12.99(2) | 75.33(1) | 0.59(2) | 645(15) | 13(3) | 5(2) | 110(20) |
| D....... | 20.047(2) | 23 46.59(2) | 50.07(2) | 0.36(5) | 160(20) | 10(4) | 8(4) | 5(40) |

Note.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.

### TABLE 3

| Source | α (J2000.0) | δ (J2000.0) | vLSR (km s^−1) | ΔvFWHM (km s^−1) | S0 (mJy beam^−1) | Notes |
|--------|--------------|-------------|----------------|------------------|------------------|-------|
| A....... | 17 47 19.94 | −28 22 13.0 | 75.31(7) | 0.71(2) | 1900 | U |
| B....... | 20.04 | 22 40.6 | 51.00(2) | 0.4(2) | 80 | U |
| D....... | 20.01 | 23 47.2 | 50.1(1) | 0.75(5) | 510 | ... |
| E....... | 18.64 | 24 24.5 | 49.1(1) | 0.94(4) | 230 | F |
| F....... | ... | ... | ... | 0.89(9) | 320 | ... |
| G....... | 19.57 | 23 49.9 | 48.7(3) | 0.8(2) | 120 | U |
| H....... | 20.43 | 23 46.7 | 70.6(3) | 0.3(2) | 50 | U |
| I....... | ... | ... | ... | 0.83(7) | 50 | U, N |
| J....... | 24.72 | 21 43.0 | 70.9(1) | 0.92(6) | 60 | ... |

Notes.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds. F = full velocity range of features observed earlier not covered; N = possible new velocity feature; U = position, velocity, and/or intensity uncertain due to blending (see § 2.2).
No circular polarization is detected in any of the H$_2$CO masers. This corresponds to a 3σ upper limit of approximately 4% circular polarization for the strongest maser (A).

3. DISCUSSION

3.1. Angular Scatter Broadening

Images of radio sources are angularly broadened by scattering by the ionized component of the interstellar medium. In the direction of the Galactic center, this problem becomes severe (e.g., Lazio & Cordes 1998). As discussed in § 2.1, J1745–283 is an extragalactic pointlike source whose image is broadened to ~30 mas at 6 cm wavelength by scattering (Bower et al. 2001). In this section we discuss the extent to which this scattering medium affects the current VLBI observations of the H$_2$CO masers in Sgr B2.

The observed size for J1745–283, 28 × 16 mas, is larger than the observed deconvolved size for the A maser, 13 × 5 mas. This result may be expected even if both sources are intrinsically pointlike, because the proximity of the maser to the scattering medium results in reduced angular broadening (e.g., Rickett 1990). Nevertheless, as discussed below, we expect significant angular broadening in the images of the masers. Therefore, the deconvolved angular sizes in Table 2 are upper limits to the intrinsic sizes, and the brightness temperatures are lower limits.

Gwinn et al. (1988) quantified the scattered sizes of H$_2$O and OH masers in Sgr B2, finding a $\lambda^{2.2}$ dependence for the broadening. From their determinations of minimum angular sizes of 0.3 mas for 1.35 cm H$_2$O masers and 100 mas for 18 cm OH masers, we expect a minimum apparent size of approximately 9 mas for the 6.2 cm H$_2$CO masers. The deconvolved angular sizes of the masers in Table 2 are in agreement with this expectation.

3.2. Variability of the H$_2$CO Masers in Sgr B2

In comparing the current VLA observations with earlier VLA data, both the differing angular resolution and spectral resolution must be considered. As discussed in § 2.2, both the differences in array configuration and in correlator setup were significant. To compensate for the difference in velocity resolution, in Table 4 we tabulate the velocity-integrated flux density for observations made in 1983 (Gardner et al. 1986), 1993 (MGP94), and 2003 and 2005 (this paper). However, it is impossible to compensate for emission outside of the velocity range covered in the current observations and for the confusion of features caused by the lower angular resolution. (The notes in the final column of Table 3 summarize limitations of the current data from these causes.) The error values in Table 4 are dominated by systematic uncertainties rather than by thermal noise in most cases.

We find that the A maser has approximately doubled in velocity-integrated flux density since 1993, while B, G, and H increased between 1983 and 1993, and subsequently decreased. The velocity-integrated flux densities from regions D, E, F, and I have not changed significantly since 1993.

3.3. Core-Halo Morphology

For the A and D H$_2$CO masers in Sgr B2, a comparison of the current VLBA+Y27 data with past and current VLA data shows two major differences: (1) only a fraction of the flux density seen with the VLA is observed in the VLBI data (~70% for the A maser; ~40% for the D maser); and (2) the velocity widths in the VLBI data are much less than in the VLA data (~80% for the A maser; ~50% for the D maser). In this section we discuss a schematic model for the structure of the emission that addresses both the observed angular distribution and velocity widths.

The flux density detected by the VLA but resolved by VLBI baselines must lie at angular scales between ~100 mas (the resolution of the shortest VLBA+Y27 interferometer spacings) and ~500 mas (the masers are unresolved in the MGP94 observations with 1′′ resolution), while the flux density observed with the VLBI is emitted by a source ~10 mas.

These limits suggest a core-halo source morphology. A similar morphology was proposed by H03 for the H$_2$CO masers in NGC 7538 and G29.96–0.02. A model consisting of two coincident circular Gaussian components with different angular sizes can reproduce the observed results. For the A maser, the flux density observed with the VLA is about 2000 mJy. To determine the decrease in flux density with increasing projected baseline length, we use the highest signal-to-noise ratio baselines only: those between Y27 and other antennas. The average flux densities observed on baselines with Y27 are: 1400 mJy at 0.71 M\(\lambda\) (to Pie Town, average projected spacing ~44 km); 1300 mJy at 3 M\(\lambda\); and 1200 mJy at 5 M\(\lambda\). These data are fit by a two-component Gaussian model with 600 mJy in a 300 mas halo and 1400 mJy in a 10 mas core.

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**TABLE 4**

**INTEGRATED FLUX DENSITY COMPARISONS (1983–2005)**

| SOURCE | 1983\(^a\) (VLA) | 1993\(^b\) (VLA) | 2003\(^c\) (VLBA) | 2005\(^c\) (VLA) |
|--------|-----------------|-----------------|-----------------|-----------------|
| A....... | 720 ± 15 | 850 ± 15 | 640 ± 50 | 1900 ± 400 |
| B........ | 80 ± 15 | 150 ± 10 | ... | 20 ± 10 |
| D........ | 700 ± 25 | 1400 ± 30 | 55 ± 20\(^d\) | 1200 ± 300 |
| E ........ | 230 ± 80 | 350 ± 20 | ... | 330 ± 30 |
| F........ | <60 | 70 ± 15 | ... | 40\(^{+50}\) |
| G........ | <30 | 320 ± 15 | ... | 75\(^{+35}\) |
| H........ | 140 ± 60 | 350 ± 15 | ... | 35 ± 20 |
| I........ | <60 | 100 ± 15 | ... | 75 ± 20 |

\(^a\) From Whiteoak & Gardner 1983.
\(^b\) From MGP94.
\(^c\) This paper.
\(^d\) Includes only one of the velocity components detected in the VLA observations.
a 10 mas core. The brightness temperature of the halo is \( T_B \approx 4 \times 10^4 \) K; for the 10 mas core component, \( T_B \approx 8 \times 10^8 \) K (Table 2; Fig. 2). A more precise model is justified only after higher signal-to-noise ratio measurements.

It is reasonable to assume that the background radiation is relatively uniform on 300 mas angular scales because the continuum emission is well resolved on the VLBA baselines. Therefore, the difference in brightness temperatures between the core and halo components may be attributed to differences in maser gain. We estimate that the halo has a gain of approximately 10 (in the exponential amplification regime) and the core has a gain of approximately 2000 (in the saturated regime). Because the observed angular sizes are upper limits for the intrinsic sizes, the derived brightness temperatures are lower limits for the intrinsic brightness temperatures; therefore, the actual gains may exceed the above values. The gain of the maser medium is dependent on four factors: the path length, the density of \( \text{H}_2\text{CO} \), the level inversion, and the velocity coherence (see § 4.2 of H03). Therefore, one or more of these factors must be significantly different between the core and halo components. We suggest that the narrower line widths arising from the core component indicate that the velocity coherence is enhanced in the core region compared to the halo, yielding a higher gain. Similar arguments may be applied to the D maser, but the resulting ranges of size and \( \Delta \theta \) are not well constrained because of the higher noise level on the VLBA–Pie Town baseline.

Additional maser species in other star-forming regions—excited \( \text{OH} \) (Palmer et al. 2003), \( \text{OH} \) in supernova remnants (Hoffman et al. 2005), as well as other \( \text{H}_2\text{CO} \) masers (H03)—exhibit a similar narrowing of line widths between VLA and VLBA angular scales.

### 3.4. Associations with Other Molecular Lines

\( \text{H}_2\text{CO} \) absorption toward Sgr B2 has been studied extensively with \( 10'' \times 20'' \) resolution by both Martin-Pintado et al. (1990) and Mehringer et al. (1995). Martin-Pintado et al. (1990) noted that the absorption is dominated by three velocity components (\( \text{v}_{\text{LSR}} = 55, 64, \) and \( 80 \) km s\(^{-1}\)), each with \( \tau > 1 \). Line widths of these absorption features ranged from \( 9 \) to \( 26 \) km s\(^{-1}\), i.e., much greater than that of the maser features (\( \lesssim 1 \) km s\(^{-1}\); see Table 3). Mehringer et al. (1995) provided optical depth profiles toward selected positions. All but maser E lie within \( 30'' \) of one of these positions displayed. (Maser E lies at a position with no radio continuum.) It is striking that the maser velocities, except for maser I (which is more than a beamwidth away from the position of a displayed profile), do not occur in velocity ranges with large \( \text{H}_2\text{CO} \) optical depths. Masers A and F occur in a velocity range with \( \tau = 1 \), but this velocity range is a rather sharp minimum in the optical depth profile at this position. Therefore, we conclude that the gas containing the \( \text{H}_2\text{CO} \) masers is distinct from the bulk of the \( \text{H}_2\text{CO} \) containing gas observed in absorption.

Insight into why the maser containing gas may be distinct is provided by (3, 3) and (4, 4) \( \text{NH}_3 \) observations made with the VLA by Martin-Pintado et al. (1999). With their 3'' resolution, 80%–90% of the \( \text{NH}_3 \) emission is resolved out, and only small angular scale features remain. Among these features are a number of rings and arcs, most naturally interpreted as complete or partial shells with linear sizes \( \approx 2 \) pc. The shells are hot (\( T_k \approx 50–70 \) K), and the \( \text{H}_2\text{CO} \) densities derived for them are typically a factor of 10 greater than those derived from the \( \text{H}_2\text{CO} \) absorption studies of Martin-Pintado et al. (1990); \( \text{H}_2\text{CO} \) masers C, D, E, G, and H fall within the field imaged by Martin-Pintado et al. (1999).

As these authors noted, all of the \( \text{H}_2\text{CO} \) masers occur at positions on hot \( \text{NH}_3 \) shells. The higher temperature (\( T_k > 100 \) K) region of apparent interaction between shells A and B contains the closely spaced D, G, and H masers. Martin-Pintado et al. (1999) proposed that the pumping mechanism for the \( \text{H}_2\text{CO} \) masers, as well as that for the \( \text{NH}_3 \) and Class II \( \text{CH}_3\text{OH} \) masers, must depend on the physical conditions in the hot shells.

In the search for additional constraints on the \( \text{H}_2\text{CO} \) emission environment, we examine the possible association of \( \text{H}_2\text{CO} \) masers with other molecular emission for which physical conditions are better understood. In Table 5 we present a summary of possible associations with \( \text{H}_2\text{O} \) masers observed by McGrath et al. (2004), \( \text{CH}_3\text{OH} \) masers observed by Houghton & Whiteoak (1995), and \( \text{OH} \) masers observed by Argon et al. (2000). The excitation conditions for the different species are mutually exclusive, but if the masers exist in a shocked region, as proposed by Martin-Pintado et al. (1999) for Sgr B2 (and for NGC 7538 by H03), a rapid change in densities, temperatures, and velocity fields over a small linear distance is to be expected. Of the \( \text{NH}_3 \) masers in Sgr B2 with interferometrically determined positions, only masers M1 and M6 lie similarly near an \( \text{H}_2\text{CO} \) maser (E), and both differ in velocity by \( >10 \) km s\(^{-1}\) from the \( \text{H}_2\text{CO} \) maser. The existence of \( \text{H}_2\text{O} \) and \( \text{CH}_3\text{OH} \) masers near the \( \text{H}_2\text{CO} \) F maser is significant because previously the F maser had no known maser or continuum associations (MGP94).

The \( \text{H}_2\text{CO} \) maser in NGC 7538 (H03) and many of those reported in § 3.2 varied in intensity with timescales from years to decades; H03 noted a common variability of some of the \( \text{H}_2\text{CO} \) masers.
and H$_2$O masers in NGC 7538. This was further confirmed by long-term observations by Lekht et al. (2003, 2004a). Similarly in Sgr B2, the long-term monitoring of the H$_2$O masers presented by Lekht et al. (2004b, 2004c) may indicate common variability of H$_2$O masers with the H$_2$CO A maser. However, variability of an H$_2$CO maser in IRAS 18566+0408 was recently seen to occur on much more rapid timescales (Araya et al. 2007).

4. CONCLUSIONS

We present VLBA+Y27 images of the Sgr B2 A and D H$_2$CO masers. The measured sizes ($<80$ AU) and brightness temperatures ($>10^8$ K) are comparable to those found in other VLBI studies of H$_2$CO masers. However, about half of the flux density from these regions is resolved out with the VLBA data. A comparison between VLA and VLBA observations shows that the missing flux density exhibits a broader line width than the emission from the compact VLBI source. We demonstrate quantitatively the applicability of a core-halo model for these masers.

We also present new VLA observations of the H$_2$CO masers in Sgr B2 with improved velocity resolution. We have detected variability in several of the masers.

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Facilities: VLA, VLBA

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