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SiO Maser Survey in the Galactic Center Region with a Multi-Beam Receiver

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Abstract

We have made a wide-field survey of SiO masers in the $7' \times 13'$ area around the Galactic center with the Nobeyama 45-m radio telescope using a 2×3 multi-beam SIS mixer receiver at 43 GHz. We detected 9 SiO maser sources (6 of them are new); newly detected 6 sources have been identified with Miras or OH 1612 MHz maser sources. The source surface number density, ~ 360 per square degree, found in this survey is slightly smaller than the number density of OH 1612 MHz sources in the same area. A least-squares analysis of the radial velocities of the detected sources has revealed a rapid rotation of the stars around the Galactic center. This implies that most of the objects detected in this survey belong to the nuclear disk near the Galactic center.

Key words: Galaxy: center — Galaxy: kinematics and dynamics — masers

1. Introduction

The number density of stellar maser sources is known to increase toward the Galactic center (Lindqvist et al. 1992a). These sources are mostly Asymptotic Giant Branch stars under heavy mass loss, where the SiO maser action occurs in the circumstellar envelope very near the photosphere (a radius of $\sim 10^{14}$ cm), while the OH maser action occurs far ($\sim 10^{16}$ cm) from the central star (Reid, Moran 1981). Stellar maser sources have been used to study the structure and dynamics of the stellar nuclear disk in the Galactic center. Though a number of SiO maser surveys of IRAS sources have been made using the Nobeyama 45-m telescope (Izumiura et al. 1995, 1999; Deguchi et al. 2000), the area within $0.^\circ5$ from the Galactic center was out of reach in these surveys because of incompleteness of the IRAS catalog in this area (Beichman et al. 1988). Shiki et al. (1997) found 6 new SiO maser sources toward the Sgr B2 molecular cloud ($l \sim 0.^\circ7$ and $b \sim -0.^\circ1$) with a non-biased mapping of a 0.154 square degree by $40''$ grid spacing. The SiO source number density is about 40 per square degree in this field, and is expected to be much larger if we proceed toward the Galactic center. In fact, Izumiura et al. (1998) found 15 SiO sources in an approximately $40'' \times 120''$ area around the Galactic center (Sgr A*) with a moderately sensitive survey, reaching to a source surface density of $\sim 4 \times 10^4$ per square degree.

On the other hand, the very sensitive OH 1612 MHz surveys towards the Galactic center using the Very Large Array yielded 254 detections within $0.^\circ5$ from the Galactic center (Sjouwerman et al. 1998; also see Lindqivist et al. 1992b; Sevenster et al. 1997). Therefore, we should find, at least, a similar number of SiO sources in this area. However, according to the past SiO maser studies (Izumiura et al. 1999), there is a minor difference in the nature between OH and SiO sources; the overlap of detected sources in both OH and SiO is only one third of the SiO detected sources in the well-studied area in both lines, the reason for which has not been well understood.

In order to find more SiO sources in the Galactic center area, we conducted a spatially non-biased SiO survey using a newly built multi-beam receiver with the Nobeyama 45-m radio telescope. The new receiver consists of 6-beam (2×3) SIS mixers working in the 40 GHz band, and can produce the spectra of two SiO maser lines (J = 1–0 v = 1 and 2) simultaneously at 6 positions with $90''$ separation in the sky. With this new instrument, we have mapped the $7' \times 13'$ area toward the Galactic center with a $30''$ grid. We detected 9 SiO maser sources in this survey. We present the results of the survey in this paper. The position of the continuum source Sgr A*, R.A. = $17^h42^m29.^s314$, Decl. = $-28^\circ59'18.''3$ (B1950) [$l_{\rm Sgr\ A^*} = -0.^\circ0557$, $b_{\rm Sgr\ A^*} = -0.^\circ0461$; Rogers et al. 1994], is regarded as the center of the Galaxy throughout this paper.

2. Observations and Results

We conducted a spatially non-biased survey of SiO maser sources in the Galactic center region with the 45-m radio telescope of the Nobeyama Radio Observatory during 2000 March 8–11 and April 15–19 in the SiO J = 1–0 v = 1 and 2 transitions at 43.122 GHz and 42.821 GHz, respectively. We used the 40 GHz-band 6-beam SIS mixer receiver (hereafter S40M) for a wide-field survey and the in-house single-beam SIS mixer receiver (hereafter S40) for confirmation ob-

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servations. For SiO line observations, we improved the S40M multi-beam receiver, which was originally designed for continuum observations to detect the Sunyaev-Zel'dovich effect toward clusters of galaxies (on this receiver, see Ohno et al. 1998; Tsuboi et al. 2000). The system temperature of the S40M receiver was 160–200 K (DSB). The measured beam size and aperture efficiency for each beam at 43 GHz with observations of 3C 273 and Jupiter were 38″ and 0.59 for channel 1, 40″ and 0.52 for channel 2, 40″ and 0.56 for channel 3, 40″ and 0.49 for channel 4, 39″ and 0.54 for channel 5, and 40″ and 0.52 for channel 6, respectively. The intensity characteristics and beam patterns of the 6 (2 × 3) beams in S40M were measured by mapping the strong SiO maser lines from VX Sgr several times prior to the mapping observations. The angular interval between each beam was designed to be $\sim 90''$. We have applied some corrections on the obtained positions of the maser sources in the S40M observations.

Acousto-optical spectrometer arrays of both high resolution (AOS-H) and wide band (AOS-W) with 2048 channels each were used; the bandwidths of AOS-H and AOS-W are 40 MHz and 250 MHz, respectively. The velocity coverages of these spectrometers at 43 GHz were about 280 km s^{-1} and 1740 km s^{-1} for AOS-H and AOS-W, respectively. The SiO $J = 1$–0 $v = 1$ and 2 transitions at 43.122 and 42.821 GHz were observed simultaneously in this system. We configured 6 AOS-W spectrometers for observing the SiO $J = 1$–0 $v = 1$ transition, and 6 AOS-H spectrometers for observing the SiO $J = 1$–0 $v = 2$ transition. A single AOS-H spectrometer covered the velocity range of only ± 140 km s^{-1}. These sources with a large velocity deviation, which were often found near to the Galactic center, were covered by the AOS-W spectrometer in the $J = 1$–0 $v = 1$ transition. The pointing of the telescope was checked almost every one or two hours using a nearby strong SiO maser source, VX Sgr. The pointing accuracy was better than $\pm 5''$ as the peak-to-peak value.

We mapped a rectangular area, $-3'.75 \le \Delta\alpha \le +3'.15$, $-6' \le \Delta\delta \le +7'$, centered at R.A. = $17^{\rm h}42^{\rm m}29^{\rm s}$, Decl. = $-28^\circ 59' 18''$ (B1950) with 30″ grid spacing. The grid was taken along R.A. and Decl. directions. The typical integration time spent per point was 2.1 min. In total, we spent about 4 hr for this wide-field mapping with the S40M receiver, and obtained spectra at 405 positions. Figure 1 shows the surveyed positions (shown by crosses). Approximately 25 candidates for SiO maser sources were found in this S40M survey. They were reobserved using the single-beam 40 GHz-band SIS mixer receiver (S40) with an image-rejection filter. The beam size and the aperture efficiency of the S40 receiver was 38″ and 0.58, respectively. The conversion factor from the antenna temperature to the flux density was 3.0 Jy K^{-1}. In this case, both the SiO $J = 1$–0 $v = 1$ and 2 transitions were observed simultaneously using the 6 high-resolution spectrometers (AOS-H) with a velocity resolution of 0.3 km s^{-1}. Three AOS-H spectrometers were configured to cover ± 350 km s^{-1} in $V_{\rm LSR}$ in each SiO line. Moreover, the 2 wide-band AOS-W spectrometers were also used for a backup of the spectra in the same frequency range. The line intensities are better calibrated by this old receiver because it has an image-rejection filter, and the efficiency, beam size, and other characteristics are better known owing to its long use.

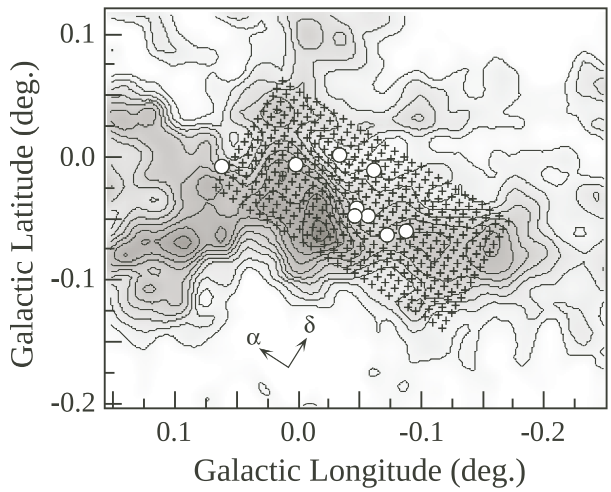

Fig. 1. Surveyed area overlaid on the CS $J = 1$–0 integrated intensity map in the velocity range of $V_{\rm LSR} = \pm 200$ km s^{-1} toward the Galactic center (Tsuboi et al. 1999). The grid points of the observation are shown by crosses, and the positions of the detected SiO maser sources are shown in open circles.

In this way, we confirmed the 9 detections of SiO maser sources in both the $J = 1$–0 $v = 1$ and 2 lines. Figure 1 shows the positions of the detected sources in the Galactic center region (open circles) overlaid on the observed grids (cross). The spectra of the detected SiO maser sources are shown in figure 2. The list of detected sources and the line parameters are given in table 1. The spectra of sources #1–#8 in figure 2 were taken using high-resolution spectrometers (AOS-H; 0.3 km s^{-1} resolution). Because the SiO line intensities of source #9 were not strong, we have shown the spectra which were taken using wide-band spectrometers (AOS-W) in both transitions, resulting in a slightly higher signal-to-noise ratio in figure 2. The line parameters shown in table 1 were derived using the high-resolution spectrometers (AOS-H).

Furthermore, in order to obtain accurate positions of the detected SiO maser sources, we made five-point mapping observations for several sources. In addition, 5 × 5 points mapping around the Galactic center with 30″ grid spacing was made using the S40 receiver.

- For sources #1–#3, we made 5-point mapping observations by 20″ separation (a half beam) around the SiO maser candidate. By a Gaussian fitting with the peak intensity at each position, we obtained accurate positions at the epoch of 1950 and position errors, which are given in table 2. An example of the 5-point mapping is shown in figure 3, illustrating the case for source #3. We obtained the positions of sources to an accuracy of about a few arcseconds with this 5-point mapping (as long as a sufficiently high S/N was available).
- For sources #4–#6, we were unable to make any 5-point mapping because of the faintness of the signal. The position errors, 20″, shown in columns 5 and 6 in table 2 corresponds to half of the diagonal separation of the observation grid on the survey. Because these sources were detected only at one position in the grid, they were lo-

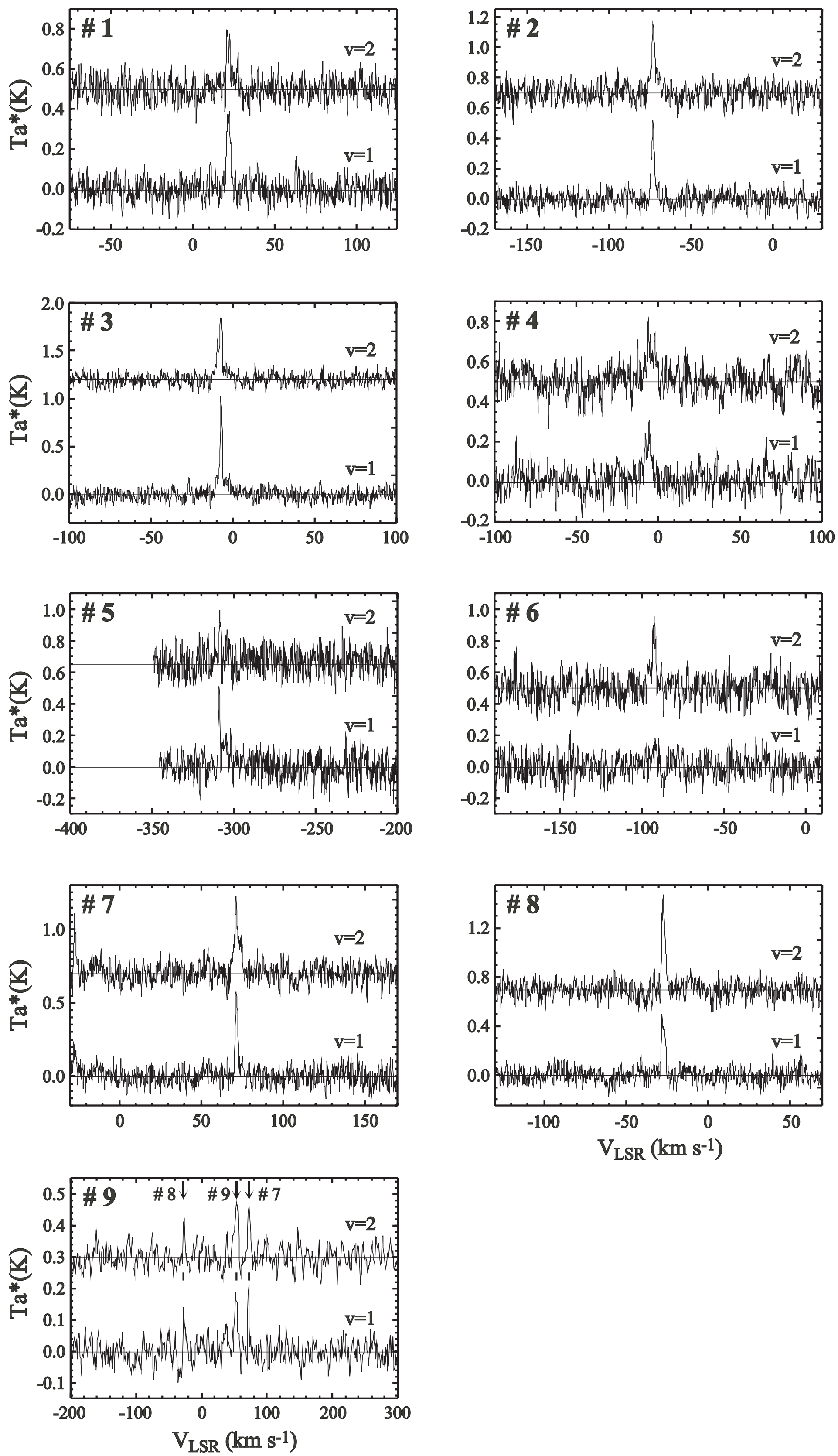

Fig. 2. SiO J = 1–0 $v = 1$ and 2 spectra for the detected sources in the Galactic center region. The spectra for sources #1–#8 were taken by high-resolution spectrometers. The spectra for source #9 were taken by wide-band spectrometers. The spectra for source #9 involves the SiO lines from sources #7 and #8 at $V_{\mathrm{LSR}} = 71$ and $-28\,\mathrm{km\,s^{-1}}$, respectively, because separations from #9 to #7 and #8 are small.

Table 1. Line parameters of the detected SiO maser sources.

No.	Name	SiO J = 1–0 v = 1				SiO J = 1–0 v = 2			
		$T^*_{\mathrm{a,peak}}$ (K)	V_{LSR} (km s^{-1})	I (K km s^{-1})	rms (K)	$T^*_{\mathrm{a,peak}}$ (K)	V_{LSR} (km s^{-1})	I (K km s^{-1})	rms (K)
1	000.062−00.006	0.39	21.8	1.08	0.049	0.30	21.8	0.79	0.052
2	359.939−00.010	0.52	−73.7	1.11	0.084	0.52	−73.5	1.11	0.082
3	359.966+00.002	1.03	−7.4	2.35	0.054	0.65	−8.1	2.23	0.053
4	000.002−00.005	0.31	−6.6	1.13	0.057	0.32	−4.8	1.32	0.060
5	359.914−00.060	0.51	−309.1	1.33	0.062	∼0.35	−308.6	0.77	0.073
6	359.928−00.063	$\lesssim$ 0.18	−92.3	$\lesssim$ 0.48	0.068	0.46	−92.9	1.34	0.070
7	359.953−00.040	0.58	71.5	1.27	0.051	0.53	71.6	1.68	0.056
8	359.944−00.047	0.50	−27.3	1.22	0.055	0.77	−27.3	1.72	0.059
9	359.954−00.048	∼ 0.26	52.1	0.67	0.069	∼0.29	52.7	1.67	0.069

Table 2. Positions of the detected SiO maser sources in the Galactic center.

No.	Name	R.A.* ($^{\mathrm{h}}$ $^{\mathrm{m}}$ $^{\mathrm{s}}$)	Decl.* (° ′ ″)	R.A. error (″)	Decl. error (″)	Remark	Possible identification
1	000.062−00.006	17 42 37.1	−28 52 01	2.2	3.2	new	1–72††
2	359.939−00.010	17 42 20.2	−28 58 27	3.3	2.9	new	OH 359.937−0.010**, 3–266††
3	359.966+00.002	17 42 21.3	−28 56 40	2.6	1.5	new	2–18††
4	000.002−00.005	17 42 28.0	−28 55 03	∼ 20†	∼ 20†	new	OH 359.998−0.005**, 2–1††
5	359.914−00.060	17 42 28.0	−29 01 18	∼ 20†	∼ 20†	new	OH 359.918−0.055**
6	359.928−00.063	17 42 30.8	−29 00 41	∼ 20†	∼ 20†	new	OH 359.931−0.063**
7	359.953−00.040	17 42 29.1	−28 58 42	$\lesssim$ 5‡	$\lesssim$ 5‡	known§	OH 359.954−0.041**
8	359.944−00.047	17 42 29.5	−28 59 19	$\lesssim$ 5‡	$\lesssim$ 5‡	known‖	OH 359.946−0.048**
9	359.954−00.048	17 42 31.0	−28 58 52	$\lesssim$ 5‡	$\lesssim$ 5‡	known♯	OH 359.956−0.050**

* Epoch of 1950.
† These position errors indicate grid spacing of survey observation.
‡ Typical errors of the positions that was estimated from the 5 × 5 mapping with 30″grid spacing (source #7–#9).
§ Lindqvist et al. (1991), Izumiura et al. (1998)
‖ IRS 10EE; Menten et al. (1997), Izumiura et al. (1998)
♯ Izumiura et al. (1998)
** Sjowerman et al. (1998); We had adopted the VLA source in this catalog if the sources had been detected overlapping in both the Very Large Array (VLA) and the Australia Telescope Compact Array (ATCA) data sets.
†† Glass et al. (2001)

cated not far from the beam center.

- For sources #7–#9, we performed 5 × 5 point mapping in (Δl, Δb) = (±1′, ±1′) around Sgr A* with 30″ grid spacing with the S40 receiver. We detected these 3 sources and obtained accurate positions by a 2-dimensional Gaussian fitting. However, the errors in the position of source #9 are still inferred to be somewhat large due to low S/N of the lines. We note that the spectra for source #9 in figure 2 involves the SiO lines from sources #7 and #8 at V_{LSR} = 71 and −28 km s^{-1}, respectively, because separations from #9 to #7 and #8 are small.

3. Discussion

The line parameters and positions of the detected SiO maser sources in the surveyed area are summarized in tables 1 and 2, respectively. The line intensities of these sources ($T^*_{\mathrm{a}} \sim$ 0.3–1.0 K) are comparable with the intensities of the relatively bright SiO sources found in the bulge SiO survey (Izumiura et al. 1998; Deguchi et al. 2000). Because of the shallowness of the present survey, it may be suspected that the detected SiO sources are not actually the Galactic center objects, but the foreground objects relatively near to the Sun. However, based on the following analysis, we show that these sources are certainly objects located near the Galactic center.

3.1. *Cross Reference Check*

We checked the positions of the detected sources with those of known SiO/OH sources in the same region (Izumiura et al. 1999; Menten et al. 1997; Lindqvist et al. 1991; Sjowerman et al. 1998). The results are shown in the last column of table 2. The radial velocities of the detected SiO masers coincide well with those of known sources within a few km s^{-1}. Catalogs of the near and middle-infrared sources in this region became available recently (Glass et al. 2001; Egan et al. 1999). Glass et al. (2001) surveyed the long-period and semi-regular variables within 12′ radius from the Galactic center in the near-infrared

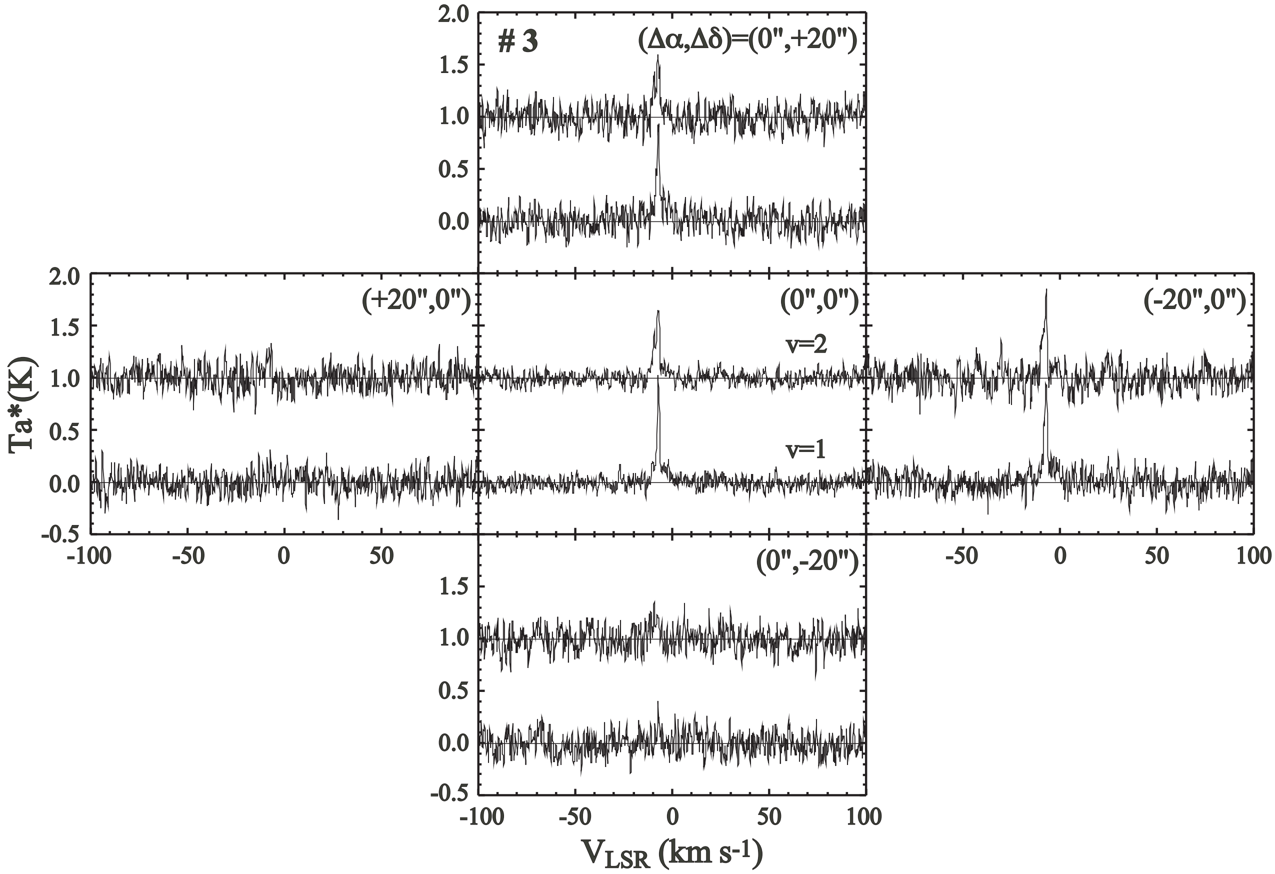

Fig. 3. Illustration of the 5 point mapping for the case of source #3. The center position is at R.A. = $17^{h}42^{m}22^{s}$, Decl. = $-28^{\circ}56'48''$ (B1950). The source position was found to be $\Delta\alpha = -10''.6$, $\Delta\delta = +8''.3$ shifted from the center.

JHK band. These stars (Miras) are the mass-losing AGB stars which often accompany OH/SiO masers. The positions of any detected SiO master sources coincide with those of Mira stars in Glass et al. (2001). The results, for which we have checked the positions, also are shown in the last column of table 2. We also checked the position coincidence of the infrared sources in the MSX catalog (Midcourse Space Experiment; Egan et al. 1999). However, no MSX source was found within 40″ radius from the SiO maser source, except for #7 and #8, which are well-known infrared objects.

With this cross checking, we found that 3 sources (#7–#9) are previously known SiO sources, and 6 sources are new detections in SiO maser lines. Among these 6 new detections in SiO masers, 4 (#2, #4–#6) have been identified with known OH 1612 MHz maser sources (Sjowerman et al. 1998); the positions coincide with these OH maser sources within 30″ and the radial velocities coincide within a few km s^{-1}.

Individually interesting objects are noted:

- Source #1 is located within 7″ from Mira star "1–72" ("2–101") of Glass et al. (2001). The *K* magnitude and the period of this Mira star "1–72" are 9.1 mag and 577 d.
- Source #2 is located within 6″ from Mira star "3–266" ("16-49") of Glass et al. (2001), which is a possible near-infrared counterpart of the OH maser source, OH 359.937−0.010 (Sjowerman et al. 1998). The *K* magnitude and the period of this Mira star "3–266" are 9.9 mag and 524 d.
- Source #3 is located within a few arcsecond from Mira star "2–18" ("3–7655") of Glass et al. (2001). The *K* magnitude and the period of this Mira star "2–18" are 9.0 mag and 667 d.
- Source #4 is located within 13″ from Mira stars "2–1" of Glass et al. (2001), which is a possible near-infrared counterpart of the OH maser source, OH 359.998−0.005 (Sjowerman et al. 1998). Although the position of the Mira star "2–10" is close to source #4 (∼ 6″), the radial velocities of the SiO source coincide with that of OH 359.998−0.005. The *K* magnitude and period of this Mira star "2–1" are 7.9 mag and 545 d.
- Source #5 is located near the OH maser source, OH 359.918−0.055 (Sjowerman et al. 1998). This source has a very high velocity (∼ −309 km s^{-1}).
- Source #6 is located near the OH maser source, OH 359.931−0.063 (Sjowerman et al. 1998; Winnberg et al. 1985). A previous SiO maser search was negative (Lindqvist et al. 1991). The line intensity of the J = 1–0 v = 1 transition was much weaker than that of the J = 1–0 v = 2 transition.
- Source #7 is located within 7″ from the OH maser source, OH 359.954–0.041 (Sjowerman et al. 1998; Winnberget at al. 1985). The detection of SiO masers

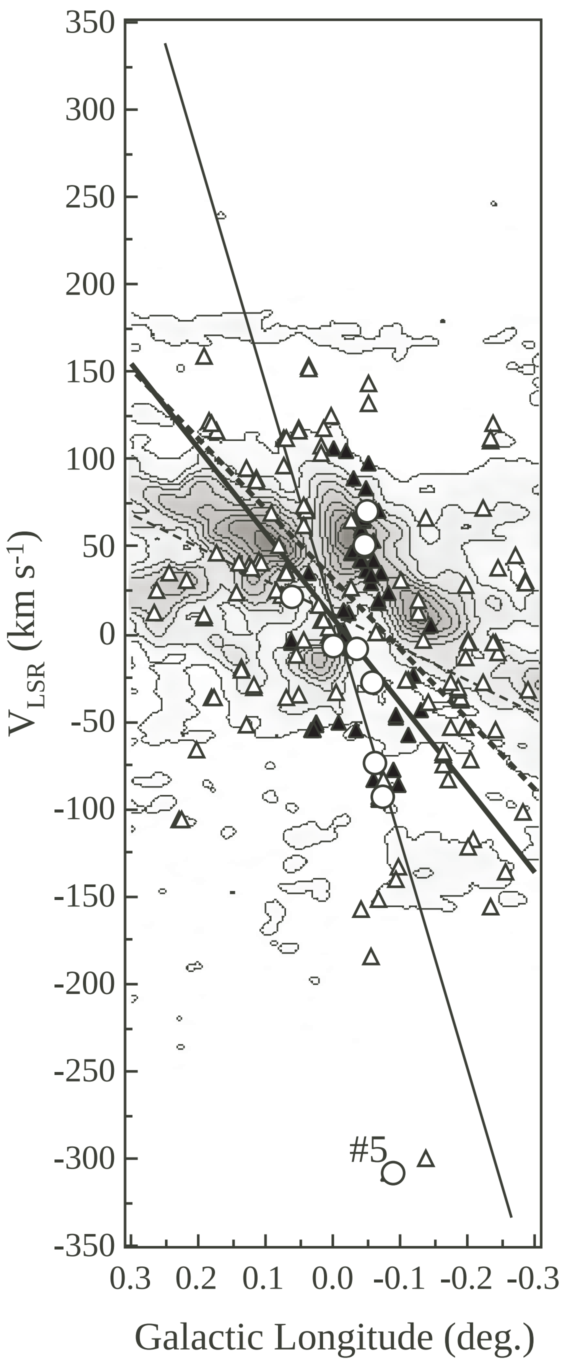

Fig. 4. Longitude–velocity (l–V) diagram for the detected SiO sources (open circles), which was overlaid on the l–V diagram averaged in the range of $-11' \le b \le +5'$ of the CS $J = 1$–0 emission line (Tsuboi et al. 1999). A least-squares fitting for all SiO sources and those excluding the extreme source #5 are shown by the thin- and thick-solid line, respectively. The triangles show the positions of the OH 1612 MHz masers (Sjouwermen et al. 1998); the filled triangles and open triangles indicate the sources that have positions located in and outside of the present survey area, respectively. The thin- and thick-dashed lines show least-squares fitting for the OH maser samples including and excluding the counterpart (OH 359.918−0.055) of source #5 and the sources outside the present survey area, respectively.

has been reported in Lindqvist et al. (1991) and Izumiura et al. (1998).

- Source #8 is the infrared source IRS 10EE (Menten et al. 1997). The OH 1612 MHz maser has been detected, OH 359.946−0.048 (Sjowerman et al. 1998). The time variation in the infrared K-band has been reported by Tamura et al. (1996) and also by Wood et al. (1998), assigning a source name, LWHM65, with $K = 7.8$ mag and a period of 736 d. Note that the peak SiO line intensities of this source in the present observations were approximately a factor of 5 stronger than those found in 1997 May by Izumiura et al. (1998).
- Source #9 is located near the OH maser source, OH 359.956−0.050 (Sjowerman et al. 1998). This SiO maser source probably coincides with the source SiO 359.955−0.046 No. 2 reported by Izumiura et al. (1998) with a radial velocity of ~ 51 km s^{-1}.

3.2. *Velocity Distribution*

Figure 4 shows a longitude–velocity (l–V) diagram for the detected SiO maser sources (shown as open circles), which is overlaid on the l–V diagram of the CS $J = 1$–0 emission line (taken from Tsuboi et al. 1999). The radial velocities of the detected SiO maser sources spread over a range between -310 km s^{-1} and 80 km s^{-1}. Sources #7 and #9 are located toward the 50 km s^{-1} molecular cloud (M−0.02−0.07; see Mezger et al. 1996). No high-velocity source with $|V_{LSR}| \ge 100$ km s^{-1} was found, except for source #5. This might be caused by an incompleteness due to the survey velocity ranges; the velocity coverage of the survey observations with S40M were different between the $v = 1$ and 2 transitions (due to a restriction of the available spectrometers, as mentioned in section 2). For the $v = 2$ transitions, it was only $|V_{LSR}| \le 140$ km s^{-1}, while it was $|V_{LSR}| \le 870$ km s^{-1} for the $v = 1$ transition. The survey sensitivity outside of ± 140 km s^{-1} was by a factor of a few worse than the range inside.

The thin-solid straight line in figure 4 shows a least-squares fitting for the 9 detected SiO sources in the surveyed region. The least-squares fitting gives

$$V_{LSR} = 1315(\pm 811)\Delta l_s(^\circ) - 65.1(\pm 37.5) \text{ km s}^{-1}, \qquad (1)$$

where Δl_s ($= l_{SiO} - l_{Sgr\ A^*}$) is the position offset from Sgr A* along the Galactic longitude. However, it may be peculiar that source #5 has an especially high velocity (~ -310 km s^{-1}), although it is expected that there are a large number of high-velocity maser sources in the Galactic center region. A least-squares fitting (thick-solid line in figure 4) for SiO sources, excluding source #5, gives

$$V_{LSR} = 490(\pm 487)\,\Delta l_s(^\circ) - 19.7(\pm 23.2) \text{ km s}^{-1}. \qquad (2)$$

On the other hand, a least-squares fitting (thick-dashed lines in figure 4) for the OH 1612 MHz maser sources in Sjouwermen et al. (1998) in a region which is comparable to the present SiO survey region ($7' \times 13'$ around the Galactic center), excluding the counterpart (OH 359.918−0.055) of source #5, gives

$$V_{LSR} = 411(\pm 149)\,\Delta l_s(^\circ) + 7.1(\pm 6.9) \text{ km s}^{-1}. \qquad (3)$$

The velocity gradient of the SiO maser source, excluding source #5, is consistent with that of the OH 1612 MHz maser sample.

The rotational motion of the SiO maser sample in the present survey is appreciably larger than the rotational speed found for the inner bulge IRAS/SiO maser sources within $|l| < 3^\circ$ and $|b| < 3^\circ$ [$22.7(\pm 7.9)\,l\,(^\circ) - 3.5(\pm 13.5)$ km s^{-1}; Deguchi et al. 2000]. The SiO sources detected in the present survey show a characteristic of the rapidly rotating, stellar nuclear disk, which was found by Lindqvist et al. (1992a) and Sjowerman et al. (1998). Therefore, we conclude that most of the SiO maser sources found in the present survey belong to the nuclear disk.

3.3. *Density of SiO Maser Sources*

We detected 9 SiO maser sources in the region of $7' \times 13'$ around the Galactic center. This corresponds to the number density of the SiO maser sources, ~ 360 per square degree. The 52 OH 1612 MHz maser sources (Sjouwermen et al. 1998) found in the same region gives a larger number density of OH 1612 MHz sources, ~ 2000 per square degree. This indicates that the present SiO survey was not deep enough. These source densities can be compared with the values obtained by previous surveys: 2.4 per square degree at the inner bulge (86 SiO maser sources in $|l| < 3^\circ$ and $|b| < 3^\circ$; Deguchi et al. 2000), or $\sim$40 per square degree towards Sgr B2 (6 SiO sources in 0.154 square degree; Shiki et al. 1997). Though the sensitivities of these surveys are not the same as that of the present survey, it is apparent that the SiO source density is increasing toward the Galactic center, as found in the OH 1612 MHz survey (Lindqvist et al. 1992a). These source densities indicate that the contamination probability of the inner bulge or the foreground sources to the present sample is quite small; a reasonable estimate involving the correction for the IRAS color range of sources in the sample by Deguchi et al. (2000) gives a contamination probability of 0.1 source in a $7' \times 13'$ area. Therefore, we conclude, again, that most of the detected SiO sources belong to the central nuclear disk.

The antenna temperature of faintest SiO maser sources detected in the present survey was $T_a^* \approx 0.3$ K. We can easily improve the sensitivity by a factor of a few by applying a longer integration time in the future (but with compensation of the survey area). It is inferred that the SiO source number density in the nuclear disk will be several-times higher than the value obtained in the present survey.

4. Summary

We have detected 9 relatively strong SiO maser sources in $7' \times 13'$ mapping observations of the Galactic center region with a $30''$ grid with a 40 GHz-band 6-beam SIS mixer receiver installed on the Nobeyama 45-m radio telescope. The source surface number density, ~ 360 per square degree, found in this survey is slightly lower than the number density of OH 1612 MHz sources in the same area. A least-squares fitting of the radial velocities with the Galactic longitude resulted in a large rotational speed around the Galactic center for this sample, indicating that these maser sources belong to the central nuclear disk. The contamination probability from the foreground source was found to be small.

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