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Citation

Kondratko, P. T., L. J. Greenhill, J. M. Moran, J. E. J. Lovell, T. B. H. Kuiper, D. L. Jauncey, L. B. Cameron, et al. 2006. "Discovery of Water Maser Emission in Eight AGNs with 70 m Antennas of NASA's Deep Space Network." *The Astrophysical Journal* 638 (1) (February 10): 100–105. doi:10.1086/498641.

Published Version

10.1086/498641

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DISCOVERY OF WATER MASER EMISSION IN EIGHT AGN WITH 70-M ANTENNAS OF NASA'S DEEP SPACE NETWORK

P. T. KONDRATKO,¹ L. J. GREENHILL,¹ J. M. MORAN,¹ J. E. J. LOVELL,² T. B. H. KUIPER,³ D. L. JAUNCEY,² AND L. B. CAMERON,⁴ J. F. GÓMEZ,⁵ C. GARCÍA-MIRÓ,⁶ E. MOLL,⁶ I. DE GREGORIO-MONSALVO,⁷ AND E. JIMÉNEZ-BAILÓN⁷

ABSTRACT

We report the discovery of water maser emission in eight active galactic nuclei (AGN) with the 70-m NASA Deep Space Network (DSN) antennas at Tidbinbilla, Australia and Robledo, Spain. The positions of the newly discovered masers, measured with the VLA, are consistent with the optical positions of the host nuclei to within 1σ ($0''.3$ radio and $1''.3$ optical) and most likely mark the locations of the embedded central engines. The spectra of two sources, NGC 3393 and NGC 5495, display the characteristic spectral signature of emission from an edge-on accretion disk, with orbital velocities of ~ 600 and $\sim 400 \text{ km s}^{-1}$, respectively. In a survey with DSN facilities of 630 AGN selected from the NASA Extragalactic Database, we have discovered a total of 15 water maser sources. The resulting incidence rate of maser emission among nearby ($v_{\text{sys}} < 7000 \text{ km s}^{-1}$) Seyfert 1.8 – 2.0 and LINER systems is $\sim 10\%$ for a typical rms noise level of $\sim 14 \text{ mJy}$ over 1.3 km s^{-1} spectral channels. As a result of this work, the number of nearby AGN ($v_{\text{sys}} < 7000 \text{ km s}^{-1}$) observed with $< 20 \text{ mJy}$ rms noise has increased from 130 to 449.

Subject headings: galaxies: active — galaxies: individual (AM2158-380NED02, IC0184, NGC0235A, NGC0613, NGC3393, NGC4293, NGC5495, VIIIZW073) — galaxies: Seyfert — ISM: molecules — ISM: jets and outflows — masers

1. INTRODUCTION

Water maser emission ($\lambda = 1.3 \text{ cm}$) is currently the only resolvable tracer of warm dense molecular gas in the inner parsec of active galactic nuclei (AGN) and has been detected to-date in approximately 60 nuclei. In eight water maser systems that have been studied with sub-milliarcsecond resolution using Very Long Baseline Interferometry (VLBI), the mapped emission appears to trace structure and dynamics of molecular disks 0.1 to 1 pc from supermassive black holes: Circinus (Greenhill et al. 2003), NGC 1068 (Greenhill & Gwinn 1997), NGC 4258 (Miyoshi et al. 1995), NGC 3079 (Trotter et al. 1998), IC 2560 (Ishihara et al. 2001), NGC 5793 (Hagiwara et al. 2001), NGC 4945 (Greenhill et al. 1997), NGC 1386 (Braatz et al. 1997). Due to spatial coherence in line-of-sight velocity within the rotating structures, maser emission is detected preferentially in edge-on disks along the midline (i.e., the diameter perpendicular to the line of sight) and close to the line of sight towards the center. A characteristic spectral signature of emission from an edge-on disk thus consists of a spectral-line complex in the vicinity of the systemic velocity (low-velocity emission) and two spectral-line complexes symmetrically offset from the systemic velocity by the orbital velocity

of the disk (high-velocity emission). Sources that display such spectra are referred to here as high-velocity systems and constitute $\sim 40\%$ of the known nuclear water masers.

The study of high-velocity systems with VLBI has significantly contributed to our understanding of the immediate vicinity (i.e., $\lesssim 1 \text{ pc}$) of supermassive black holes. In three of these systems — NGC 4258 (Miyoshi et al. 1995), NGC 1068 (Greenhill & Gwinn 1997), and the Circinus Galaxy (Greenhill et al. 2003) — resolved position and line-of-sight velocity data provided evidence for differential rotation and enabled accurate estimation of black hole mass and pc-scale molecular disk structure. Another system, NGC 3079, in which the rotation curve traced by the maser emission appears flat, was interpreted in the context of a pc-scale, thick, edge-on, self-gravitating, and possibly star forming molecular disk (Kondratko et al. 2005; Yamauchi et al. 2004). In addition to mapping pc-scale molecular disk structure and accurately weighing supermassive black holes, nuclear water maser emission has also been used as a distance indicator. Distance determination is possible for systems where a robust pc-scale disk model from VLBI maps is combined with a measurement of either maser proper motions or drifts in line-of-sight velocity of spectral features (i.e., centripetal acceleration). The distance to NGC 4258 obtained in this manner is the most accurate extragalactic distance thus far, is independent of standard candle calibrators such as Cepheids (Herrnstein et al. 1999), and it has contributed to analysis of the Cepheid period-luminosity relation (Freedman et al. 2001; Newman et al. 2001).

The ~ 60 known nuclear water masers are in the great majority of cases associated with Seyfert 1.8 – 2.0 or LINER nuclei; only five systems are exceptions: NGC 5506 (NLSy1 from Nagar et al. 2002; Braatz et al. 1996), NGC 4051 (Sy1.5 from the NED; Hagiwara et al. 2003), NGC 2782 (Sy1, starburst from the NED;

¹ Harvard-Smithsonian Center for Astrophysics, 60 Garden St, Cambridge, MA 02138 USA

² Australia Telescope National Facility, CSIRO, Epping, NSW 2121 Australia

³ Jet Propulsion Laboratory, 4800 Oak Grove Dr, Pasadena, CA 91109 USA

⁴ Raytheon, Canberra Deep Space Communications Complex, Tidbinbilla Rd, Paddy's Creek, ACT 2609, Australia

⁵ Instituto de Astrofísica de Andalucía, CSIC, Apartado 3004, E-18080 Granada, Spain

⁶ Madrid Deep Space Communication Complex, INTA-NASA, Paseo del Pintor Rosales 34-bajo, E-28008 Madrid, Spain

⁷ Laboratorio de Astrofísica Espacial y Física Fundamental, INTA, Apartado 50727, E-28080 Madrid, Spain
Electronic address: pkondrat@cfa.harvard.edu

Braatz et al. 2004), NGC 4151 (Sy1.5 from the NED; Braatz et al. 2004), and 3C 403 (FRII; Tarchi et al. 2003). In the context of the unified AGN model, Seyfert 1.8–2.0 systems contain an active nucleus and an obscuring structure along the line of sight to the central engine (Lawrence & Elvis 1982; Antonucci 1993). Irradiation of molecular gas by X-rays from the central engine is a plausible means of exciting maser emission (e.g., Neufeld, Maloney, & Conger 1994), which might explain the association of maser emission with nuclear activity in general. Maser emission might be associated with Seyfert 1.8–2.0 systems in particular because, over a range of AGN luminosity, the shielding column density that provides the obscuring geometry maintains not only a reservoir of molecular gas but also physical conditions conducive to maser action, which are temperatures of 250–1000 K and H_2 number densities of $10^{8-10} \text{ cm}^{-3}$ (e.g., Desch, Wallin, & Watson 1998). Since there is good evidence for a physical relationship between LINER systems and the AGN phenomenon (e.g., Ho et al. 1997b; Ho 1999; Ho et al. 2003), the distinction between these two types of activity in the context of maser emission might simply be one of luminosity, whereby a large fraction of LINERs correspond to low-luminosity analogues of Seyfert 1.8–2.0 systems.

Since water maser emission is typically weak ($\ll 0.1 \text{ Jy}$) and the velocity range of emission is determined by the orbital velocity of the molecular disk ($\gg 100 \text{ km s}^{-1}$), surveys designed to detect new water maser sources require both large, sensitive apertures and wide bandwidth spectrometers. The detection rate of water maser emission among Seyfert 2 and LINER galaxies with $v_{sys} < 7000 \text{ km s}^{-1}$ is $\sim 4\%$ for surveys with a typical rms noise level on each source of $\sim 60 \text{ mJy}$ (thereafter, sensitivity; Braatz et al. 1996). This low detection rate, the weakness of the emission, and its potential wide velocity range make the discovery of new water maser sources challenging. Most past survey work has been characterized by limited sensitivity ($\sim 60 \text{ mJy}$) and narrow bandwidths ($\sim 700 \text{ km s}^{-1}$) and thus might have missed new maser sources because the emission was either too weak or outside the observing bands. These limitations of the previous surveys provide the major impetus for the present work. We note that a recent survey with $\sim 3 \text{ mJy}$ sensitivity (converted to 1.3 km s^{-1} spectral channels) using the Green Bank Telescope (GBT) has yielded a detection rate of $\sim 20\%$ among Seyfert 2 and LINER systems with $v_{sys} < 7500 \text{ km s}^{-1}$, though it was limited to just 145 sources (Braatz et al. 2004).

In order to discover more high-velocity systems, we procured a custom-built 4096-channel spectrometer with 5300 km s^{-1} bandwidth and are conducting a survey with the 70-m NASA Deep Space Network (DSN) antennas at Tidbinbilla, Australia and at Robledo, Spain. We selected our sample from among 1150 AGN with $v_{sys} < 14600 \text{ km s}^{-1}$ listed in the NASA Extragalactic Database (NED), with preference for Seyfert 1.8–2.0 and LINER systems at lower recessional velocities. Thus far, we have discovered water maser emission in 15 AGN. The first seven discoveries were reported in Greenhill et al. (2003); here, we present spectra of eight most recent detections.

2. OBSERVATIONS

The discoveries reported here were obtained during the 2004–2005 northern winter with the Robledo 70-m antenna and during the 2003 and 2005 southern winters with the Tidbinbilla 70-m antenna. The observing system at Tidbinbilla and its calibration was described in Greenhill et al. (2003). The observing system setup at Robledo was identical to that at Tidbinbilla. We estimated the gain curve and aperture efficiency of the Robledo antenna through measurement of opacity corrected antenna temperature of 3C 147, for which we adopted a flux density of 1.82 Jy at 22.175 GHz (Baars et al. 1977). The resulting peak efficiency was 0.43 ± 0.09 at $43^\circ \pm 5^\circ$ elevation, which yields a sensitivity of $1.7 \pm 0.3 \text{ Jy K}^{-1}$.

To obtain single-polarization total-power spectra of each source, we moved the telescope every 30 or 45 s between the target source and a reference position on the sky $\sim 0.2^\circ$ away. Antenna rms pointing errors were typically $7''$ and system temperatures ranged from 40 to 75 K depending on elevation and weather. Typical 1σ noise levels attained in an integration time (on+off source) of one hour were $\sim 8 - 17 \text{ mJy}$ in a 1.3 km s^{-1} channel. The spectra reported here have been Hanning smoothed to an effective resolution of 3.5 km s^{-1} and corrected for atmospheric opacity estimated from tipping scans.

3. RESULTS

During the 2003 and 2005 southern winters, we detected maser emission in six AGN with the Tidbinbilla antenna: AM 2158-380 NED02, IC 0184, NGC 0235A, NGC 0613, NGC 3393, and NGC 5495 (Fig. 1 and Table 1). Maser emission from NGC 4293 and VII ZW 073 was detected during the 2004–2005 northern winter with the Robledo antenna. Each discovery was confirmed by at least one observation with another instrument (Table 1). Positions of the maser emission measured with the Very Large Array (VLA) of the NRAO⁸ are consistent with optical positions of the AGN to within 1σ ($0''.3$ radio and $1''.3$ optical; Table 1), which confirms the association of the discovered emission with nuclear activity.

The nuclei that are host to the detected maser emission are spectroscopically classified as Seyfert 2 or LINER in all but two cases (Table 1). Ambiguity remains in the case of NGC 0613, which is listed as a possible Seyfert by Veron-Cetty & Veron (1986), and in the case of NGC 0235A, which is classified as Seyfert 2 by Monk et al. (1986) but as Seyfert 1 by Maia et al. (1987). There is some indication of a broad component in $H\alpha$ in the optical spectrum presented by Maia et al. (1987) (the Monk et al. (1986) spectrum does not cover the wavelength of $H\alpha$). However, optical spectra presented by Monk et al. (1986) and Maia et al. (1987) exhibit a narrow $H\beta$ line and a strong $[O III]\lambda 5007$ line relative to $H\beta$. According to the quantitative classification scheme of Winkler (1992) (see also Osterbrock 1977, 1981), NGC 0235A thus harbors either a Seyfert 1.9 or a Seyfert 2 nucleus. A spectrum obtained independently by J. Huchra (2004, private communication) confirms this classification. It is thus likely that NGC 0235A was misclassified based on the hint of broad $H\alpha$ reported by Maia et al. (1987).

⁸ The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under cooperative agreement with the National Science Foundation

The maser spectrum of NGC 3393 shows a characteristic spectral signature of emission from an edge-on disk: two high-velocity complexes (~ 70 mJy) symmetrically offset by ~ 600 km s $^{-1}$ from the systemic velocity and a single spectral complex (~ 28 mJy) within 120 km s $^{-1}$ of the systemic velocity. We have confirmed the weak systemic feature with the Tidbinbilla antenna ($1\sigma = 7$ mJy) and with the GBT ($1\sigma = 2$ mJy in a 0.33 km s $^{-1}$ spectral channel). If the high-velocity emission indeed originates from the midline of an edge-on disk, then the orbital velocity of the disk as traced by the maser emission is ~ 600 km s $^{-1}$, making NGC 3393 the third fastest known rotator after NGC 4258 (~ 1200 km s $^{-1}$; Miyoshi et al. 1995) and ESO269-G012 (~ 650 km s $^{-1}$; Greenhill et al. 2003). Because the high-velocity emission extends over $\Delta v \sim 200$ km s $^{-1}$, it must occupy a fractional range of radii $\Delta r/R \approx 2\Delta v/v = 2/3$, which yields $\Delta r \sim 0.15 - 0.57$ pc, assuming Keplerian rotation ($v \propto r^{-0.5}$) and a range in disk sizes from that of NGC 4258 (0.16 – 0.28 pc) to NGC 1068 (0.6 – 1.1 pc). The corresponding central mass would be on the order of $5 \times 10^7 M_\odot$ and the anticipated centripetal acceleration — that is the secular velocity drift of the systemic feature — would be on the order of 1 km s $^{-1}$ yr $^{-1}$, which should be readily detectable within one year using single dish monitoring.

We confirmed the detection of high-velocity lines in NGC 5495 (refer to Fig. 1) with the GBT ($1\sigma = 5$ mJy in a 0.33 km s $^{-1}$ spectral channel). If we again assume that the high-velocity emission originates from the midline of an edge-on disk, then the orbital velocity of the accretion disk is ~ 400 km s $^{-1}$ while the corresponding central mass and centripetal acceleration are on the order of $10^7 M_\odot$ and 0.5 km s $^{-1}$ yr $^{-1}$, respectively, assuming disk sizes as in NGC 4258 and NGC 1068.

Each of the remaining six detections — AM 2158-380 NED02, IC 0184, NGC 0235A, NGC 0613, NGC 4293, and VII ZW 073 — displays only a single complex of spectral features. In particular, the spectrum of NGC 0613 reveals a very broad emission feature (full width at half-maximum of ~ 87 km s $^{-1}$) and such broad lines have been typically associated with radio jets rather than molecular disks (e.g., Peck et al. 2003; Claussen et al. 1998). The spectral lines in NGC 0235A, VII ZW 073, and IC 0184 are significantly displaced from systemic velocities of the host galaxies (by ~ 380 , ~ 180 , and ~ 220 km s $^{-1}$, respectively) and thus might be either emission features associated with radio jets (e.g., Peck et al. 2003; Claussen et al. 1998) or high-velocity emission lines from only a single side of an edge-on accretion disk. NGC 0613, NGC 3393, NGC 4293, and IC 0184 have been targeted but not detected in previous surveys for maser emission. For NGC 0613, Braatz et al. (1996) and Henkel et al. (1984) report 1σ noise levels of 364 mJy and 70 mJy in 1.7 and 1.3 km s $^{-1}$ spectral channels, respectively, corresponding to signal-to-noise ratios of $\lesssim 1$ at the current line strength (peak flux of ~ 70 mJy in a 1.3 km s $^{-1}$ spectral channel). Considering the large line-width, broader spectral averaging could have been applied to Henkel et al. (1984) data to achieve a marginal detection, and it is thus unclear whether this observation indicates line variability analogous to that observed in other masers associated with jet activity (e.g., Peck et al. 2003). For NGC 3393, Braatz et al.

(1996) report 1σ noise level of 11 mJy in 0.66 km s $^{-1}$ channels, which should have been sufficient to detect the maser emission at its present strength of ~ 80 mJy (in a 1.3 km s $^{-1}$ channel). In the case of NGC 4293, J. A. Braatz (private communication) obtained in 1998 a 1σ noise level in a 1.3 km s $^{-1}$ channel of 35 mJy, which would not have been sufficient to detect the weak emission (peak of ~ 40 mJy in a 1.3 km s $^{-1}$ channel). For IC 0184, Braatz et al. (1996) report 1σ noise level of 63 mJy in 0.66 km s $^{-1}$ channels, again not sufficient to detect the maser at present line strength (peak of ~ 27 mJy in a 1.3 km s $^{-1}$ channel).

In a survey with the Tidbinbilla and Robledo antennas of 630 AGN with $v_{sys} < 14600$ km s $^{-1}$ selected from the NED (Table 2), we have detected to-date 15 new water maser sources (this paper and Greenhill et al. 2003). Since previous searches for water maser emission reported detections mostly in Seyfert 1.8 – 2.0 or LINER systems (e.g., Braatz et al. 1996), we have focused our survey primarily on obscured nuclei (488 Seyfert 1.8 – 2.0 or LINER systems, among which there are the 15 new maser sources, and 143 Seyfert 1.0 – 1.5 systems, for which we report no new detections). Our survey includes 55% of known AGN with $v_{sys} < 14600$ km s $^{-1}$ (630 out of 1150) and is nearly complete to 7000 km s $^{-1}$ with 82% of Seyfert 1.8 – 2.0 and LINER systems (325 out of 398) already observed, although AGN catalogs consolidated by the NED may themselves be incomplete. The detection rate among nearby ($v_{sys} < 7000$ km s $^{-1}$) Seyfert 1.8 – 2.0 and LINER galaxies is 4%. The detection rate among nearby Seyfert 1.8 – 2.0 and LINER galaxies that have been observed with absolute sensitivity (i.e., 1σ noise level in flux density units multiplied by the spectral channel width and converted to luminosity using $H_0 = 75$ km s $^{-1}$ Mpc) of better than $2 L_\odot$ is 4%, consistent with the analogous detection rate of 6% reported by Braatz et al. (1996). However, taking into account all known maser sources with peak flux densities above four times the typical rms achieved in this survey ($4\sigma = 56$ mJy or $15 L_\odot$ in a 1.3 km s $^{-1}$ spectral channel at $v_{sys} = 7000$ km s $^{-1}$), the resulting incidence rate of maser emission among nearby Seyfert 1.8 – 2.0 and LINER systems is $\sim 10\%$, which should be compared to the analogous incidence rates of $\sim 7\%$ and $\sim 20\%$ for surveys with ~ 60 mJy (~ 1 km s $^{-1}$ spectral channels; Braatz et al. 1996) and ~ 3 mJy (converted to 1.3 km s $^{-1}$ spectral channels; Braatz et al. 2004) sensitivities, respectively. Six of the detections obtained with DSN (NGC 0613, NGC 3393, NGC 4293, NGC 5643, NGC 6300, and IC 0184) lie in nuclei that had been targeted in previous surveys, which demonstrates the importance of either survey sensitivity or source variability. As a result of this work, the number of nearby AGN ($v_{sys} < 7000$ km s $^{-1}$) observed with < 20 mJy sensitivity has increased from 130 to 449.

4. FUTURE PROSPECTS

Four of the fifteen detections obtained using the 70-m antennas of the DSN — NGC 3393, NGC 5495 (this study), ESO 269-G012, and possibly NGC 6926 (Greenhill et al. 2003) — display the archetypal spectral signature of emission from an edge-on disk. The remaining 11 sources appear to be non-high-velocity systems, but monitoring and deep integrations (as with the GBT,

which is roughly an order of magnitude more sensitive than the DSN antennas) may result in detection of high-velocity features. All high-velocity systems stronger than few mJy are good candidates for follow-up high angular resolution study with VLBI, where pc-scale molecular disk geometry and black hole mass may be inferred directly from resolved position and line-of-sight velocity data with high accuracy and relatively few sources of systematic uncertainty. Assuming disk sizes of 0.1 to 1 pc (i.e., comparable to NGC 4258 and NGC 1068, respectively) and a VLBI resolution element of ~ 0.3 mas, the source structure should be readily resolved because the AGN are relatively nearby ($3704 \text{ km s}^{-1} < v_{\text{sys}} < 6589 \text{ km s}^{-1}$). The additional detection with single dish spectroscopic monitoring of secular drift in the velocities of low-velocity Doppler components (i.e., centripetal acceleration) may also enable estimation of geometric distances, as has been done for NGC 4258 (Herrnstein et al. 1999). A geometric distance to any of these systems would be of considerable value since it might help in calibration of the Hubble relation independent of standard candles such as Cepheids.

We are grateful for the invaluable support provided by the management, operations, and technical staff of the Canberra and Madrid Deep Space Communications Complexes. We thank M. Franco for Radio Frequency support and most especially P. Wolken and the staff charged with scheduling antenna time, without whose help and guidance this project would have been impossible. This research has made an extensive use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory (JPL), California Institute of Technology, under contract with NASA. This work was supported in part by R&D funds of the Smithsonian Astrophysical Observatory. IdG and JFG are partially supported by grant AYA2002-00376 (FEDER funds) of the Ministerio de Educación y Ciencia (Spain). Canberra Deep Space Communication Complex is managed by Commonwealth Scientific and Industrial Research Organisation (CSIRO) on behalf of JPL for NASA, with operations and maintenance undertaken by Raytheon, Australia. The Australia Telescope National Facility is funded by the Commonwealth Government for operation as a national facility by the CSIRO.

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FIG. 1.— Spectra of NGC 3393, NGC 5495, NGC 0235A, NGC 0613, VII ZW 073, NGC 4293, AM 2158-380 NED02, and IC 0184 obtained with the 70-m Deep Space Network antennas at Tidbinbilla, Australia and Robledo, Spain. The arrows indicate NGC 5495 high-velocity features confirmed with the GBT. The velocity was computed in accordance with the radio definition of Doppler Shift and in the heliocentric reference frame. Vertical bars depict systemic velocities of the host galaxies and respective uncertainties.

TABLE 1
NEWLY DISCOVERED NUCLEAR MASERS.

Galaxy	Type ^(a)	α_{2000} ^(b) (hhmmss)	δ_{2000} ^(b) (ddmmss)	v_{sys} ^(c) (km s ⁻¹)	$\log_{10} L_{H_2O}$ ^(d) ($\log_{10} L_{\odot}$)	Date ^(e) (ddd-yy)	T ^(f) (s)	1σ ^(g) (mJy)	Misc ^(h)
NGC 0235A	Sy2	00 42 52.81	-23 32 27.7	6519	2.0	214-03	2280	15	TV
		00 42 52.81	-23 32 27.8						BnA
NGC 0613	Sy	01 34 18.23	-29 25 06.6	1468	1.2	174-03	1680	16	TV
		01 34 18.18	-29 25 06.5						BnA
IC 0184	Sy2	01 59 51.23	-06 50 25.4	5287	1.4	183-05	8760	7	GV
		01 59 51.23	-06 50 25.4						CnB
VII ZW 073	Sy2	06 30 25.57	+63 40 41.2	11899	2.2	337-04	19560	6	GRV
		06 30 25.54	+63 40 41.3			353-04			B
NGC 3393	Sy2	10 48 23.46	-25 09 43.4	3704	2.4	167-03	6120	8	GTV
		10 48 23.45	-25 09 43.6			174-03			BnA
NGC 4293	LINER	12 21 12.89	+18 22 56.6	890	0.1-0.7	056-04	15420	5	RV
		12 21 12.82	+18 22 57.4			063-04			B
NGC 5495	Sy2	14 12 23.35	-27 06 28.9	6589	2.3	215-03	2820	10	GV
		14 12 23.35	-27 06 29.2						BnA
AM 2158-380 NED02	Sy2	22 01 17.07	-37 46 24.0	9661	2.7	175-05	11460	7	GTV
		22 01 17.10	-37 46 23.0			178-05			CnB

^(a) Activity type. NGC 5495 is classified as Seyfert 2 by Kirhakos & Steiner (1990), NGC 3393, IC 0184, VII ZW 073, and AM 2158-380 NED02 are listed as Seyfert 2 in the Veron-Cetty catalogue (Veron-Cetty & Veron 2003), NGC 0613 is classified as a possible Seyfert by Veron-Cetty & Veron (1986), NGC 4293 is listed as LINER by Ho et al. (1997a), while NGC 0235A is classified as Seyfert 1 by Maia et al. (1987) but as Seyfert 2 by Monk et al. (1986). Refer to the text for the discussion of the ambiguity in NGC 0235A spectral classification.

^(b) *First line*: optical positions from the NED with uncertainties of $\pm 1''3$. *Second line*: maser positions measured with a VLA snapshot with typical uncertainties of $\pm 0''3$. In an effort to test for systematic errors in the derived maser positions, we imaged disjoint segments of the VLA data and confirmed that they yield consistent maser positions (that is, within $0''3$).

^(c) Heliocentric systemic velocity computed assuming the radio definition of Doppler shift.

^(d) Total water maser luminosity assuming isotropic emission of radiation and distances based on $H_0 = 75 \text{ km s}^{-1} \text{ Mpc}^{-1}$, except for for NGC 0613 and NGC 4293, whose distances were adopted to be 17.9 Mpc (Jungwiert et al. 1997) and 17 Mpc (Tully 1988), respectively.

^(e) Data obtained at listed epochs were combined to form a single spectrum.

^(f) Total integration time on+off source.

^(g) Rms noise in a 1.3 km s^{-1} spectral channel, corrected for atmospheric opacity (typically ~ 0.07) and for the dependence of antenna gain on elevation.

^(h) *First line*: Instruments used to confirm the initial detections: G=GBT, R=Robledo, T=Tidbinbilla, V=VLA. The velocities and flux densities of the narrow spectral peaks in AM 2158-380 NED02, NGC 0235A, NGC 3393, NGC 5495, and NGC 4293 detected with the VLA agree with those measured using the Tidbinbilla antenna to within 1.3 km s^{-1} and 30%, respectively. On the other hand, a 6 km s^{-1} discrepancy in the velocity centroid of the NGC 0613 spectral-line likely reflects uncertainty due to noise in the Tidbinbilla spectrum. Although the peak flux densities of the IC 0184 maser agree to within 20%, the velocity centroids are in disagreement by 5 km s^{-1} , which is again most likely due to low signal-to-noise ratio in the Tidbinbilla spectrum. The strengths of the VII ZW 073 maser measured with the VLA and the Robledo antenna differ by a factor of 2.5 (time baseline of 5 months), which could be due to either maser variability or low signal-to-noise ratio in both spectra. We note that such variability is not unusual (e.g., Baan & Haschick 1996). The flux densities of AM 2158-380 NED02, IC 0184, NGC 3393, NGC 5495, and VII ZW 073 measured with the DSN and the GBT antennae agree to within 25%. (The GBT spectra will be presented in a follow-up article.) *Second line*: Configuration of the VLA. The VLA bandwidth was 6.25 MHz (channel spacing of 1.3 km s^{-1}) for all imaged sources except NGC 0613, where a wider bandwidth of 25 MHz (channel spacing of 11 km s^{-1}) was necessary in order to include all the emission.

TABLE 2
SOURCES SURVEYED FOR WATER MASER EMISSION WITH 70-M DEEP SPACE NETWORK ANTENNAS AT
TIDBINBILLA AND ROBLED0. [REFER TO THE SOURCE FOR THE COMPLETE VERSION OF THIS TABLE.]

Galaxy Name	Type ^(a)	α_{2000} ^(a) (hhmmss)	δ_{2000} ^(a) (ddmmss)	v_{sys} ^(a) (km s ⁻¹)	Date	T ^(b) (s)	1σ ^(c) (mJy)	Site ^(d)
KUG2358+330	SY2	00 00 58.14	+33 20 38.1	12387	2005-01-05	6240	9	R
UGC12914	LINER	00 01 38.32	+23 29 01.5	4308	2003-02-03	2910	18	R
UGC12915	LINER	00 01 41.94	+23 29 44.5	4274	2004-07-20	2460	12	T
CGCG517-014	SY2	00 01 58.46	+36 38 56.6	9311	2004-12-26	6060	9	R
NGC7814	LINER	00 03 14.89	+16 08 43.5	1046	2002-08-15	1980	14	T
UGC00013	LINER	00 03 29.23	+27 21 05.9	7498	2002-12-25	2100	23	R

^(a)Type, position, and heliocentric systemic velocity obtained from the NED at the outset of the survey in 2002. Velocities are computed assuming the radio definition of Doppler shift.

^(b)Total integration time on+off source.

^(c)Rms noise in a 1.3 km s⁻¹ spectral channel, corrected for atmospheric opacity (typically ~ 0.07) and for the dependence of antenna gain on elevation.

^(d)R=Robledo, T=Tidbinbilla.