1990RMxAA..20...51G

Rev. Mexicana Astron. Astrof., 20, 51-54 (1990)

NEW H_2O MASERS IN COLOR-SELECTED IRAS POINT SOURCES

A.L. Gyulbudaghian

Byurakan Astrophysical Observatory, Armenian SSR, USSR

L.F. Rodríguez and S. Curiel

Instituto de Astronomía, UNAM, and
Harvard-Smithsonian Center for Astrophysics

Received 1990 January 4

RESUMEN

Utilizando el radiotelescopio del Observatorio de Haystack, buscamos emisión de maser de agua en 21 fuentes puntuales IRAS seleccionadas en base a sus colores. Los criterios de selección a partir de los colores IRAS fueron los propuestos por Wouterloot y Walmsley (1986). Detectamos 9 máseres, de los cuales 7 son nuevas detecciones. Nuestra tasa de detección del 43 por ciento es significativamente mayor que las obtenidas en encuestas previas de fuentes puntuales IRAS e indica que los criterios de Wouterloot y Walmsley pueden ser utilizados para la detección eficiente de nuevos máseres de agua.

Uno de los máseres detectados por nosotros, el asociado con IRAS 21144+5430, es muy brillante y sobreluminoso con respecto a la luminosidad IRAS de la región. Su velocidad radial muy negativa sugiere que se encuentra en el brazo de Perseo, a una distancia de 4 a 6 kpc, lo cual lo haría uno de los máseres de agua más luminosos de la Galaxia. Observamos esta región con el Conjunto Muy Grande (*VLA*), poniendo un límite superior de 0.3 mJy para la emisión de radiocontinuo a 6-cm en la vecindad del maser.

ABSTRACT

Using the Haystack radio telescope, we searched for H_2O maser emission toward 21 color-selected IRAS point sources. The color selection criteria were those proposed by Wouterloot and Walmsley (1986) for H_2O masers. We detected 9 masers, of which 7 are new detections. Our detection rate of 43 percent is significantly higher than those obtained in previous surveys of IRAS sources and indicate that the criteria of Wouterloot and Walmsley can be used for the efficient detection of new water masers.

One of the masers detected by us, that associated with IRAS 21144+5430, is very bright and overluminous with respect to the IRAS luminosity of the region. Its large negative radial velocity suggests it is located in the Perseus arm, at a distance of 4 to 6 kpc, which would make it one of the most luminous water masers in the Galaxy. We observed this region with the Very Large Array and set an upper limit of 0.3 mJy for the 6-cm continuum emission in the vicinity of the maser.

Key words: **MASERS – INFRARED SOURCES – STARS-FORMATION**

I. INTRODUCTION

Water maser emission is considered to be a tracer of recent star formation activity (Reid and Moran 1988). About 342 interstellar water masers are known north of $\delta = -30°$ (Cesaroni *et al.* 1988).

Wouterloot and Walmsley (1986) searched for water emission in 265 IRAS point sources in the Orion and Cepheus regions. They detected 27 masers, of which 13 were new detections. From their results, Wouterloot and Walmsley concluded that water masers appear mainly in sources whose IRAS color indices fall in well-defined ranges. Using the convention $[\lambda_i - \lambda_j] = \log\,[\mathrm{Flux}(\lambda_i)/\mathrm{Flux}(\lambda_j)]$, the ranges of the color indices for H_2O masers obtained by Wouterloot and Walmsley are $0.5 \leq [25-12] \leq 1.1$, $0.4 \leq [60-25] \leq 1.7$, and $-0.1 \leq [100-60] \leq 0.5$. Here the numbers inside the square brackets are in microns. Scalise, Rodríguez,and Mendoza-Torres (1989) observed 146 bright, unassociated IRAS point sources

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System

1990RMxAA..20...51G

TABLE 1

IRAS POINT SOURCES OBSERVED

IRAS	Position		IRAS Fluxes (Jy)				H_2O Maser Emission	
	$\alpha(1950)$	$\delta(1950)$	12μm	25μm	60μm	100μm	S_L(Jy)	v_{LSR} (km s^{-1})
21015+5918	$21^h01^m33\overset{s}{.}9$	+59°18′53″	6.6	6.7	61.9	107.7	$\leq 3^a$	–
21144+5430	21 14 24.1	+54 30 57	1.2	14.9	75.2	91.2	450	-88.4
21173+5450	21 17 21.2	+54 50 37	0.7	2.3	27.5	59.7	4	-82.7
21184+5507	21 18 26.9	+55 07 07	1.0	2.9	64.9	152.8	$\leq 3^a$	–
21246+5512	21 24 40.9	+55 12 54	1.8	10.3	69.8	120.2	$\leq 3^a$	–
21336+5333	21 33 41.1	+53 33 45	7.2	39.1	190.6	291.1	$\leq 3^a$	–
21340+5339	21 34 04.1	+53 39 31	3.1	28.8	97.3	258.2	$\leq 3^a$	–
21368+5456	21 36 52.3	+54 56 47	2.7	16.1	71.1	109.7	13	-56.7
21388+5622	21 38 53.2	+56 22 18	2.4	17.4	52.5	75.2	130	-3.9
21391+5802	21 39 10.3	+58 02 29	0.6	8.9	144.5	424.6	9,35	-5.2,2.7
21413+5442	21 41 21.2	+54 42 30	44.9	248.9	1127.2	1270.6	$4,9^b$	-70.4,-59.8
21418+5403	21 41 48.2	+54 03 09	4.5	26.6	140.6	178.7	$\leq 3^a$	–
21445+5712	21 44 30.8	+57 12 29	3.0	11.4	34.7	87.1	$\leq 4^a$	–
21479+5510	21 47 59.1	+55 10 47	0.3	1.5	14.3	32.2	6	-74.3
21512+5625	21 51 16.7	+56 25 41	3.6	15.6	87.9	173.8	$\leq 4^a$	–
21519+5613	21 51 58.3	+56 13 34	1.7	18.4	109.7	151.4	$\leq 4^a$	–
21526+5728	21 52 39.8	+57 28 38	3.4	14.3	109.7	207.0	$\leq 3^a$	–
21542+5558	21 54 12.1	+55 58 42	2.4	12.7	31.1	24.4	6	-50.1
21548+5747	21 54 50.9	+57 47 17	2.7	8.0	122.5	251.2	$\leq 4^a$	–
21561+5806	21 56 06.0	+58 06 45	1.7	5.4	50.6	83.2	8	-71.2
22036+6034	22 03 38.8	+60 34 04	0.8	3.3	18.5	30.2	$\leq 3^a$	–

a. Four-sigma upper limit. b. Spectrum contains other weaker features.

detecting 23 new water masers. They found, for the sources with associated water maser emission, ranges of IRAS color indices similar to those derived by Wouterloot and Walmsley.

In this note we report the search for H_2O maser emission in 21 IRAS point sources whose color indices fall within or close the criteria given by Wouterloot and Walmsley (1986). These IRAS point sources are located in the Cygnus-Cepheus region.

II. OBSERVATIONS AND RESULTS

The observations were made in 1988 July 7-9 and 1988 November 26-27 using the 37-m radio telescope of the Haystack Observatory[1]. At the frequency of the $6_{16} - 5_{23}$ transition of water vapor (22 235.080 GHz), the beam size is 1.5 arc min and the aperture efficiency about 0.30 at an elevation of 45°. The receiver was a cooled K-band maser and the spectrometer a 512-channel digital autocorrelator. The effective bandwidth was 13.3 MHz (~179 km s^{-1}) and the spectral resolution was 0.88 km s^{-1} after Hanning weighting. All the spectra were corrected for elevation-dependent gain variations and for atmospheric attenuation. The rms pointing error of the telescope was ~20 arc sec. The observations were made using position switching and 10 minutes of total integration time per source. Additional spectra were obtained for the detections.

1. Radio Astronomy at Haystack Observatory of the Northeast Radio Observatory Corp., is supported by a grant from the National Science Foundation.

The list of 21 objects (Table 1) was surveyed in both epochs. The 1988 July observations were made under poor weather conditions and even then

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System

1990RMxAA..20...51G

sources were found to have associated H_2O maser mission. The 1988 November observations were ade under excellent weather conditions and a tal of 9 masers were detected (the 6 detected reviously plus 3 weaker ones). The fluxes and elocities for these 9 masers are given in Table 1 and fer to the 1988 November data. The linewidths ere in the range of ~0.5 to 2.0 km s^{-1} . In e same table we list the upper limits for the non etections.

Our detection rate of 43 percent is significant- higher than the values of 10 and 16 percent otained by Wouterloot and Walmsley (1986) and calise, Rodríguez, and Mendoza-Torres (1989), re- spectively. This higher detection rate simply reflects e fact that we have taken advantage of the criteria reviously established by them.

Consulting the catalog of Cesaroni *et al.* (1988) e found that 2 of our 9 detections had al- eady been found in unpublished observations of Vouterloot. These sources are IRAS 21542+5558 nd IRAS 21561+5806. The remaining 7 ma- ers do not appear in the Cesaroni *et al.* (1988) atalog and thus appear to be new detections. nterestingly enough, two of the sources observed y us and not detected, IRAS 21512+5625 and RAS 21519+5613, are reported in the Cesaroni *al.* (1988) catalog as detected, also in unpublished bservations of Wouterloot. Then, the total detec- on rate is 52 percent. This result suggests that mo- itoring of the list will probably reveal additional ew masers.

The LSR radial velocities of the masers fall in two roups. IRAS 21388+5622 and IRAS 21391+5802 ave LSR radial velocities close to 0 km s^{-1} . The ther 7 detections have LSR radial velocities with rge negative values, going from about −50 to bout −90 km s^{-1}. The low velocity masers are ost probably located in the Cepheus and Cygnus olecular cloud complexes, with distances of 500 o 700 pc (Dame *et al.* 1987), while the masers with rge negative velocities are most probably located n the Perseus arm, at a distance of 4 to 6 kpc (Blitz, ich and Stark 1982).

III. THE REMARKABLE H_2O MASER ASSOCIATED WITH IRAS 21144+5430

The most remarkable of the water masers detec- ed by us is that associated with IRAS 21144+5430. The position determined for the maser from five- oint maps with half-beam separation coincides, vithin the pointing error of the Haystack telescope about 20 arc sec), with the IRAS position. A ra- io interferometric measurement is required to es- ablish more accurately the maser position.

When first detected in 1988 July 8, the peak lux density of the maser was 1280 Jy. By 1988 November 26, the peak flux density had dropped to 450 Jy (the value given in Table 1). Our last observation of this maser, made in 1988 December 28, shows that the peak flux density had increased to 600 Jy (Figure 1). In all three observed epochs the maser spectrum consisted of a single, narrow (~0.5 km s^{-1}) feature centered at −88.4 km s^{-1}. If, as suggested by its large negative radial velocity, this maser is located in the Perseus arm, it is one of the most luminous H_2O masers in the Galaxy.

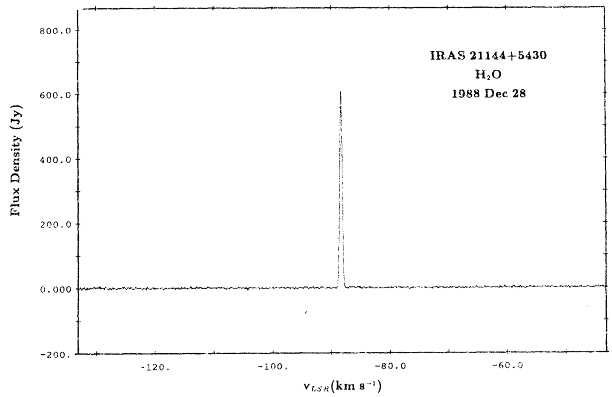

Fig. 1.Spectrum of the H_2O maser emission associated with IRAS 21144+5430. The horizontal axis is radial velocity with respect to the LSR, given in km s^{-1} , and the vertical axis is flux density given in Jy. The velocity resolution of this spectrum is 0.13 km s^{-1}.

This maser is overluminous with respect to the far infrared luminosity of the region. From the results of Wouterloot and Walmsley (1986), we estimate that for galactic H_2O masers, $L_{H_2O}/L_{FIR} \sim 10^{-9\pm1}$. The H_2O maser associated with IRAS 21144 +5430 has reached ratios of $L_{H_2O}/L_{FIR} \sim 10^{-7}$, far in excess of the typical ratios.

During 1988 August 26 we made 6-cm continuum observations of the region using the Very Large Array of NRAO[2]. At the epoch of the observations the *VLA* was in the D configuration, providing an angular resolution of about 10 arc sec at 6-cm. We did not detect radio continuum emission within one arc min of the maser position, setting a 4-σ upper limit of 0.3 mJy. The positions and fluxes of the sources detected in the region are given in Table 2.

IV. CONCLUSIONS

We observed, using the Haystack radio telescope, 21 color-selected IRAS point sources search-

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

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System

1990RMxAA..20...51G

TABLE 2

DETECTED 6-cm SOURCES IN THE IRAS 21144+5430 REGION

Source	$\alpha(1950)^a$	$\delta(1950)^a$	Flux Density[b] (mJy)
1	$21^h\ 13^m\ 41.4^s$	$+54^\circ\ 29'\ 48''$	2.0
2	21 13 56.8	+54 31 31	0.6
3	21 14 11.0	+54 30 14	0.6
4	21 14 12.9	+54 33 29	0.6
5	21 14 19.7	+54 25 11	1.2
6	21 14 28.0	+54 35 16	3.1
7	21 14 52.5	+54 32 14	9.1
8	21 14 56.1	+54 31 57	1.8

a. Position of peak emission. Positional error is $2''$

b. Peak value corrected for primary beam response. The 1-σ rms noise is 80 μJy.

ing for water maser emission. We detected 9 sources, of which 7 are new detections. Our detection rate of 43 percent is significantly higher than those obtained in previous surveys of IRAS sources (Wouterloot and Walmsley 1986; Scalise Rodríguez, and Mendoza-Torres 1989) and reflects the fact that we have used the selection criteria established by Wouterloot and Walmsley (1986) and confirmed by Scalise, Rodríguez, and Mendoza-Torres (1989).

One of the masers detected by us, that associated with IRAS 21144 +5430, is very bright and overluminous with respect to the IRAS luminosity of the region. We observed the region with the *VLA* and placed an upper limit of 0.3 mJy for 6-cm continuum emission in the vicinity of the maser.

REFERENCES

Blitz, L., Fich, M., and Stark, A. A. 1982, *Ap. J. Suppl.*, **49**, 183.

Cesaroni, R. *et al.* 1988, *Astr. and Ap. Suppl.*, **76**, 445.

Dame, T. M. *et al.* 1987, *Ap. J.*, **322**, 706.

Reid, M. J. and Moran, J. M. 1988, in *Galactic and Extragalactic Radio Astronomy*, ed. G. L. Verschuur and K. I. Kellermann (Springer-Verlag: New York) p. 255.

Scalise, E., Rodríguez, L. F., and Mendoza-Torres, E. 1989, *Astr. and Ap.*, **221**, 105.

Wouterloot, J. G. A. and Walmsley, C. M. 1986, *Astr. and Ap.*, **168**, 237.

Salvador Curiel: Center for Astrophysics, 60 Garden St., Cambridge, MA, 02138, USA.

Armen L. Gyulbudaghian: Byurakan Astrophysical Observatory, Byurakan, Armenian SSR, USSR.

Luis F. Rodríguez: Instituto de Astronomía, UNAM, Apdo. Postal 70-264, 04510 México, D.F., México.

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System