THE ASTROPHYSICAL JOURNAL, **250**:621–630, 1981 November 15

NEW H_2O MASERS ASSOCIATED WITH FAR-INFRARED SOURCES

D. T. JAFFE,[1] R. GÜSTEN,[2] AND D. DOWNES[3]
Received 1981 March 16; accepted 1981 May 19

ABSTRACT

We have searched for H_2O masers in the direction of far-infrared sources found in a recent survey. There are 25 H_2O masers near the 42 far-IR sources, of which 13 masers are new detections. Many of the far-IR sources are in the general vicinity of compact H II regions, and are thus likely to be young objects. Our results are consistent with a 50–100% coincidence of H_2O masers with far-IR sources, suggesting that such objects are even more suitable candidates for maser searches than the compact H II regions. The high coincidence rate implies a lifetime of more than 2×10^5 years for the maser phase. The large velocity differences between the H_2O features and the molecular clouds in the directions of these sources are similar to those observed in the more well-known H_2O sources studied by VLBI. As in those sources, the velocities imply mass loss. Hence the far-IR sources are probably not "protostars" in a phase of pure contraction.

Subject headings: infrared: sources — masers — nebulae: H II regions

I. INTRODUCTION

Water vapor masers at 22 GHz are found in the envelopes of evolved stars and in the vicinity of newly formed OB stars. We have searched for water vapor masers in the direction of far-infrared sources from the recent survey with the Center for Astrophysics–University of Arizona balloon telescope (Jaffe, Stier, and Fazio 1982, hereafter JSF; Stier *et al.* 1982, hereafter S82). That survey covered a region in the galactic plane between $l=10°$ and $16°$ (see Fig. 1) with a $\sim1'$ resolution 40–250 μm broad-band photometer. In this region, there are 42 far-IR sources, seven of which are members of the H II region complexes M17 and W33. The flux densities of the weakest sources detected were 350 Jy at 70 μm, for an assumed 70 K blackbody spectrum. Only 23 of the far-IR sources appear as radio continuum sources in the surveys of Altenhoff *et al.* (1978) or Haynes, Caswell, and Simons (1979). There are 33 radio continuum sources within the survey region with sizes less than 4′ and 5 GHz flux densities greater than 100 mJy, with undetected far-IR counterparts. That is, about half of the radio continuum sources were detected in the far-IR, and vice versa. JSF determined kinematic distances for molecular clouds in the direction of the far-IR sources from their ^{12}CO and ^{13}CO observations and detected eight of the far-IR sources in the radio continuum at levels below the flux limit of previous surveys.

We report here on 25 H_2O masers located near the far-IR sources. Thirteen of the masers are new detections, and one of these, M17(4), is a new source in a region with several previously known H_2O masers. We also report an improved position for an H_2O maser inside the survey region (14.17−0.06; Batchelor *et al.* 1980) which has no far-IR counterpart.

II. OBSERVATIONS

The H_2O observations were made in 1979 November and 1980 April with the Effelsberg 100 m telescope, with the same equipment and sensitivity described by Genzel and Downes (1977*a*). We searched around the nominal position of the far-IR sources by mapping an area of typical diameter 80″ to a limit of ~10 Jy over the velocity range -25 to $+105$ km s^{-1}. For some extended far-IR sources, we covered a larger area. We determined the source positions by making cross scans with grid spacings of $\pm20''$ or $\pm30''$. The telescope pointing was checked on NRAO 530. Three of the new H_2O sources have more accurate positions, which we measured relative to the nearby H_2O maser 12.2−0.1(1), for which there is an interferometric position good to 1″ (Welch *et al.*, reported by Shaver and Danks 1978).

III. RESULTS

Table 1 lists the H_2O masers within the region of the far-IR survey. The approximate H_2O maser luminosity (col. [13]) was calculated for isotropic radiation. Column (8) gives the velocity of the associated CO cloud, column (11) the kinematic distance computed from the ^{12}CO velocity (JSF) and the rotation curve of Gunn, Knapp, and Tremaine (1979), and column (12) the corresponding far-IR luminosity (JSF).

The heavy lines in Figure 1 outline the far-IR survey region. The diagonal line through the figure shows the

[1] Harvard-Smithsonian Center for Astrophysics.
[2] Max-Planck-Institut für Radiostronomie, Bonn.
[3] Institut de Radio Astronomie Millimétrique, Grenoble.

TABLE 1

PARAMETERS OF H_2O/FAR-IR SOURCES

H_2O SOURCE l^{II}, b^{II} (1)	H_2O POSITION R.A. (1950) (2)	H_2O POSITION Decl. (1950) (3)	ERROR IN H_2O position (4)	FAR-IR SOURCE l^{II}, b^{II} (5)	FAR-IR POSITION R.A. (1950) (6)	FAR-IR POSITION DEC. (1950) (7)
12.42+0.50	18h07m56.s4	−17°56′37″	10″	12.41+0.50	18h07m53.s8	−17°57′10″
12.89+0.49	18 08 56.3	−17 32 16	10	12.89+0.48	18 08 58.4	−17 32 24
12.76+0.33	18 09 15.6	−17 43 35	4	12.78+0.33	18 09 17.4	−17 42 36
12.21−0.10	18 09 43.70	−18 25 09.0	1	12.21−0.10	18 09 44.4	−18 25 04
12.21−0.12	18 09 48.5	−18 25 25	4	12.21−0.10	18 09 44.4	−18 25 04
12.22−0.12	18 09 48.6	−18 25 17	6	12.21−0.10	18 09 44.4	−18 25 04
12.68−0.18	18 10 59.24	−18 02 40.3	0.3	12.70−0.17	18 10 58.6	−18 01 20
13.19+0.04	18 11 11.5	−17 29 13	7	13.19+0.05	18 11 09.3	−17 29 20
12.81−0.20	18 11 18.3	−17 56 21	5	12.81−0.19	18 11 17.4	−17 56 16
13.87+0.28	18 11 41.5	−16 46 34	6	13.88+0.29	18 11 40.8	−16 46 12
12.91−0.26	18 11 44.0	−17 53 09	5	12.91−0.26	18 11 44.8	−17 52 40
14.11+0.09	18 12 52.6	−16 39 59	10	14.10+0.10	18 12 49.8	−16 39 44
14.17−0.06	18 13 31.9	−16 41 03	10	...	...	...
14.49+0.01	18 13 55.5	−16 21 46	10	14.48+0.02	18 13 52.6	−16 22 08
12.43−1.12	18 13 56.1	−18 42 57	10	12.43−1.12	18 13 56.9	−18 42 59
14.60+0.02	18 14 08.1	−16 15 46	7	14.60+0.02	18 14 06.7	−16 15 36
14.45−0.11	18 14 16.4	−16 27 20	10	14.47−0.11	18 14 18.6	−16 26 16
13.66−0.60	18 14 30.3	−17 23 22	10	13.66−0.60	18 14 29.6	−17 23 12
14.23−0.51	18 15 18.8	−16 50 47	6	14.21−0.53	18 15 21.4	−16 52 00
14.33−0.64	18 16 00.8	−16 49 06	5	14.33−0.64	18 15 59.2	−16 48 48
14.63−0.58	18 16 21.2	−16 31 24	6	14.63−0.59	18 16 24.1	−16 31 32
15.034−0.666	18 17 29.2	−16 12 41	8	15.02−0.67	18 17 28.0	−16 13 40
14.99−0.70	18 17 30.0	−16 16 03	5	15.02−0.67	18 17 28.0	−16 13 40
15.030−0.673	18 17 30.3	−16 13 06	4	15.02−0.67	18 18 28.8	−16 13 40
15.04−0.67	18 17 31.1	−16 12 51	5	15.02−0.67	18 17 28.8	−16 13 40
15.20−0.63	18 17 40.4	−16 03 01	9	15.20−0.62	18 17 39.8	−16 02 32

NOTE.—^{12}CO velocities, distances, and far-IR luminosities are from Jaffe, Stir, and Fazio 1981.

PREVIOUS H_2O REFERENCES.—(1) Genzel and Downes 1977*b*. (2) Shaver and Goss 1978. (3) Johnston, Sloanaker, and Bologna 1973. (4) Batchelor *et al.* 1980. (5) Lada *et al.* 1976.

NOTES.—(a) Wright *et al.* (1979) far-IR position. (b) Welch *et al.*, cited in Shaver and Danks (1978) H_2O position. (c) Genzel and Downes (1977*b*) H_2O parameters and position. (d) OH maser (Goss *et al.* 1977). (e) OH maser W33B (Wynn-Williams, Werner, and Wilson (1974); Lada *et al.* (1981) H_2O position. (f) Genzel and Downes (1977*b*) H_2O position. (g) W33 continuum. (h) OH maser W33A (Wynn-Williams, Werner, and Wilson 1974). (i) $S<350$ Jy at 70 μm; see text. (j) M17(4). (k) M17(1) (l) M17(2). (m) M17(3) (n) Cesarsky *et al.* (1978) possibly detected H_2O emission at a different position. See text.

TABLE 1—*Continued*

^{12}CO Velocity (km s^{-1}) (8)	Velocity of Strongest H_2O Component (km s^{-1}) (9)	Velocity Centroid of of H_2O Features (km s^{-1}) (10)	Distance to Source (kpc) (11)	far-IR Luminosity ($10^4 L_\odot$) (12)	Isotropic H_2O Luminosity ($10^{-6} L_\odot$) (13)	Previous H_2O Refs. (14)	Notes (15)
20	10	...	2.3	2.5	0.8	...	a
34	32	32	3.6	6.2	200	...	
20	22	...	2.3	1.8	2	...	
27	−7	4	13.4	110	30000	1,2	b
27	...	25	13.4	110	...	1,2	c
27	...	33	13.4	110	...	1,2	c,d
36	59	58	3.8	<6	600	1,3	e
54	−21	...	4.7	26	8	1	f
36	32	35	3.7	150	20	1	f,g
49	21	...	4.4	20	4	1	f
36	38	39	3.7	10	10	1	f,h
12	8	...	1.6	0.4	1	...	
...	62	45	...	...	...	4	i
41	18	—	3.8	1.7	2	...	
42	−41	−40	4.1	7.4	800	...	
40	20	...	3.7	13	2	1	f
41	37	48	3.8	6.4	4	...	
50	48	54	4.4	3.5	200	...	
22	25	29	2.3	1.1	40	...	
23	23	12	2.3	2.3	30	...	
20	26	...	2.3	1.3	4	...	
20	23	?	2.3	290	4	...	j
20	13	3	2.3	290	40	1,5	f,k
20	20	?	2.3	290	10	1,3	f,l
20	−43	?	2.3	290	5	1	f,m
22	47	33	2.3	27	1	...	n

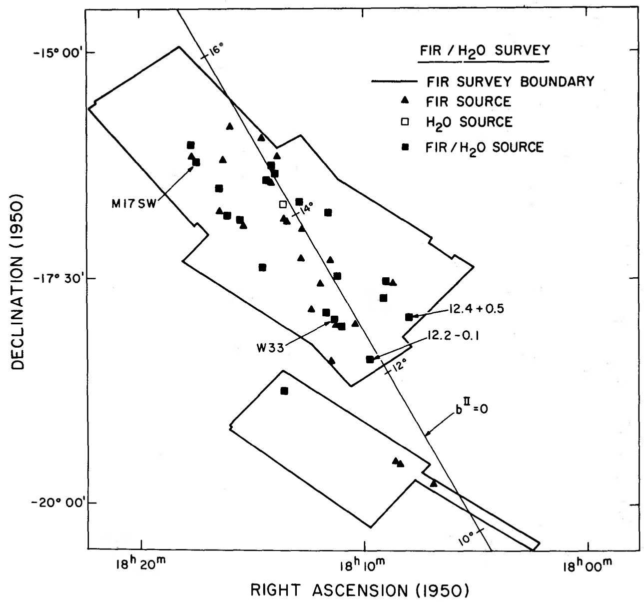

FIG. 1.—Location of the far-IR and H_2O sources on the sky. The heavy lines outline the far-IR survey region (Jaffe, Stier, and Fazio 1981). The diagonal line through the figure shows the position of the galactic plane. Galactic longitude is marked at 2° intervals. The triangles give the positions of far-IR peaks without associated H_2O emission, the open square shows the location of the H_2O maser with no detectable far-IR counterpart, and the filled squares represent the H_2O/far-IR sources.

position of the galactic plane. The triangles represent far-IR sources with no associated H_2O maser emission, the open square represents the H_2O maser with no associated far-IR source, and the filled squares represent the H_2O/far-IR sources.

Figures 2*a*–2*c* show spectra of all of the H_2O masers within the survey region with the exception of 12.21−0.12 and 12.22−0.12. Note that earlier spectra of the previously observed sources may be found in Genzel and Downes (1977*b*, hereafter GD77).

IV. REMARKS ON INDIVIDUAL SOURCES

a) 12.2−.1

This source is the only far-IR survey source likely to be at the far kinematic distance (S82). Downes *et al.* (1980) report an H_2CO absorption line toward this source at 119 km s^{-1}. The ^{12}CO velocity of the source is 27 km s^{-1} (JSF). In addition, a comparison of the angular extent and velocity spread of the H_2O maser emission argues against the near kinematic distance (see S82). The centroid of the maser emission from 12.21−0.10 is -25 km s^{-1} from the CO velocity. The emission is spread over 45 km s^{-1} with as many as 20 individual velocity components visible in single-dish spectra. This spectrum is similar to those of W51 Main and W51 N (Genzel *et al.* 1978, 1979). The basic shape of the spectrum is unchanged from that in the first observations in late 1976 (Goss *et al.* 1977; GD77). The H_2O maser is coincident to within 2″ with a compact (diameter 2″) radio continuum source (Shaver and Danks, 1978). The H_2O luminosity is more than 10 times that of the next strongest survey source. There is an OH maser close to another of the H_2O masers in this complex (12.22−0.12; Evans, as reported by Shaver and Danks 1978).

b) 12.42+0.50

The position of the H_2O source is 10″ ± 10″ from the position of the 20 μm source discovered by Beichman (1979). Radio continuum emission has been detected in the direction of the 20 μm source (JSF).

c) 12.43−1.12

The H_2O emission from this source is at a velocity ~ -80 km s^{-1} from the CO velocity. There is no maser emission at the velocity of the cloud. The broad, smooth spectrum of this source is similar to that of W3(OH).

d) 12.68−0.18(W33B)

The maser position is significantly offset from the peak of the far-IR source 12.70−0.17. Lada *et al.* (1981) have determined the maser position to an accuracy of 0″.3. The velocity centroid of the maser emission differs by 20 km s^{-1} from the CO velocity but is close to the higher velocity component of the double hydrogen recombination lines seen toward this source (Gardner, Wilson, and Thomasson 1975; Goss, Matthews, and Winnberg 1978; Bieging, Pankonin, and Smith 1978). There is an OH maser near the H_2O position (Wynn-

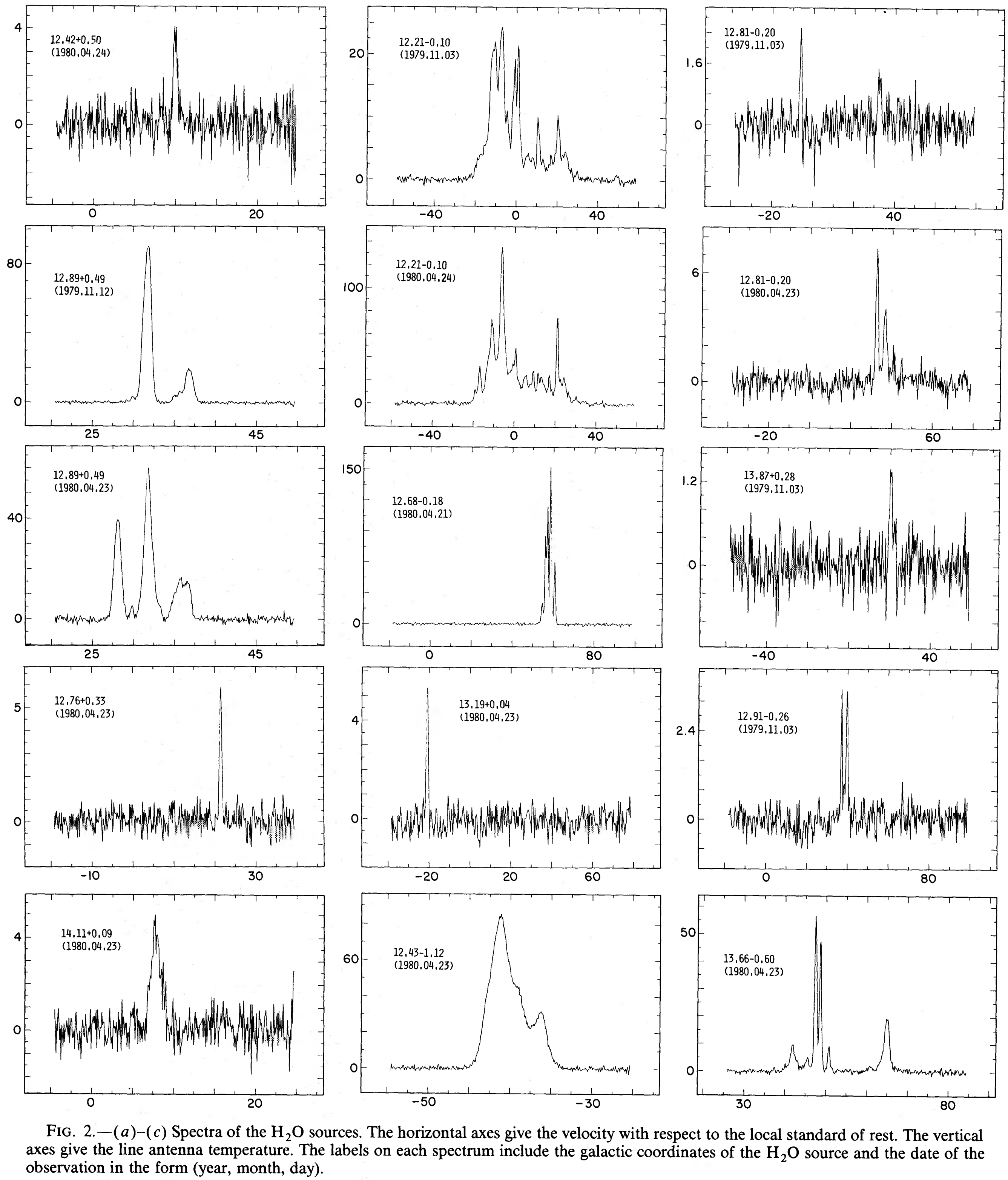

FIG. 2.—(*a*)–(*c*) Spectra of the H_2O sources. The horizontal axes give the velocity with respect to the local standard of rest. The vertical axes give the line antenna temperature. The labels on each spectrum include the galactic coordinates of the H_2O source and the date of the observation in the form (year, month, day).

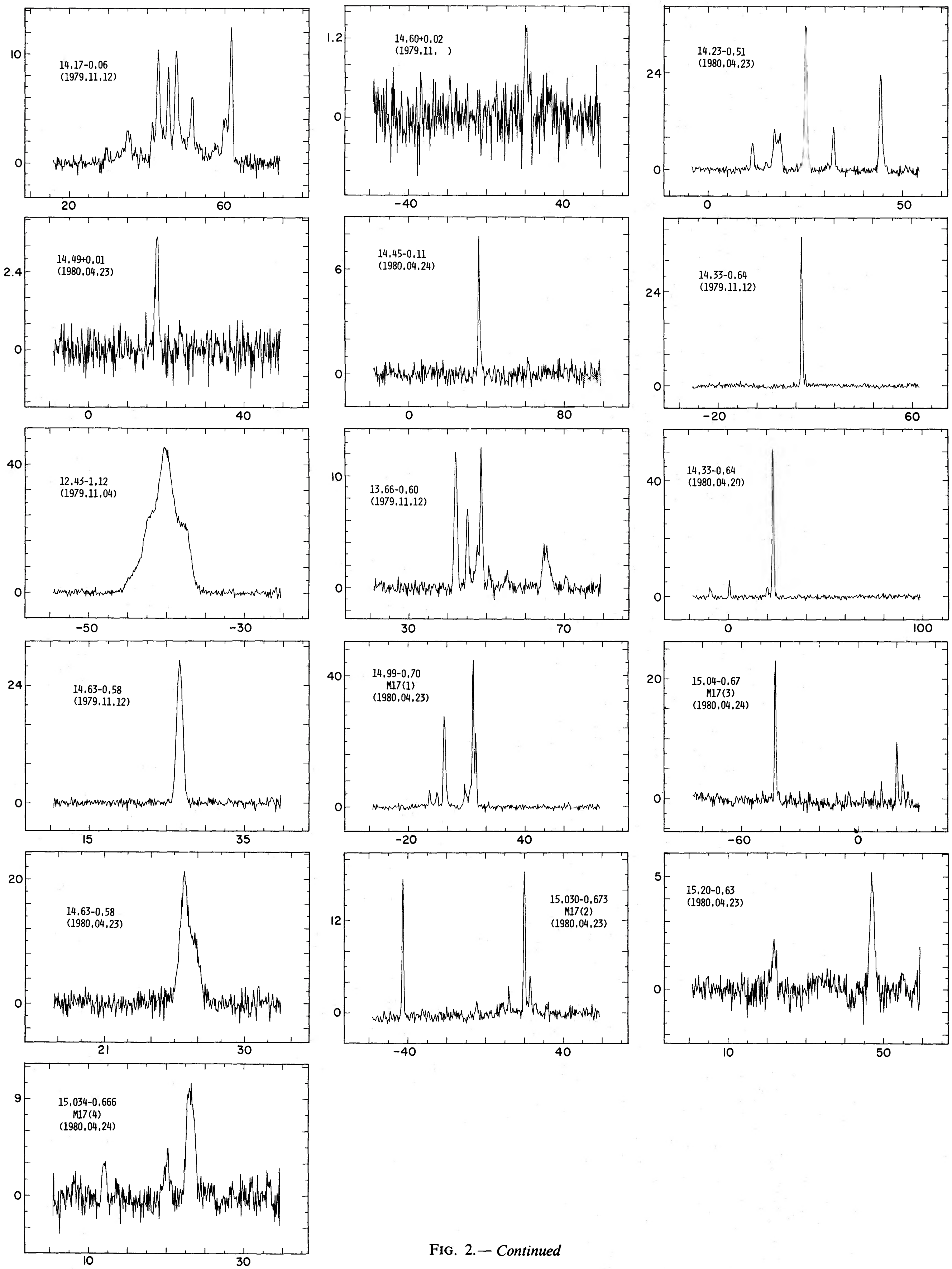

FIG. 2.— *Continued*

Williams, Werner, and Wilson 1974), as well as extended radio continuum emission (Habing *et al.* 1974; Wynn-Williams, Beichman, and Downes 1981).

e) 12.81−0.20 (W33 continuum)

The maser position (GD77) is 10″±7.5″ from the position of the 20 μm source W33 IRS2 (Dyck and Simon 1977). The −2 km s^{-1} feature seen in 1976 November had been replaced by a feature at −7 km s^{-1} 3 years later. In 1980 April this feature was no longer detectable. The H_2O maser seems to lie between two extended radio peaks (Wynn-Williams, Beichman, and Downes 1981). There is also an OH maser in the vicinity (Paschenko 1980).

f) 12.91−0.26 (W33A)

The H_2O maser is 9″±5″ from a compact near-infrared source (Capps, Gillett, and Knacke 1978). This infrared source has an extremely deep 10 μm absorption feature and the deepest known 3 μm absorption feature, indicating a hot, underlying source surrounded by a dense, cool cloud. The OH maser observed toward this source (Wynn-Williams, Werner, and Wilson 1974) is coincident (within ±4″) with the near-infrared source. There is no 5 GHz radio continuum emission greater than 5 mJy from either the infrared or maser sources (Wynn-Williams, Beichman, and Downes 1981).

g) 13.19−0.04

The only detectable feature in the spectrum of this source was at −21 km s^{-1}. In 1976 November there was a single group of features at −2 km s^{-1} (GD77). The CO velocity of this source is 54 km s^{-1}. This was one of five sources with a single H_2O line at a velocity greater than 10 km s^{-1} from the CO velocity.

h) 13.87+0.28

In 1976 November this source had features at −8 and −21 km s^{-1}. In 1979 November the only detectable feature was at +20.5 km s^{-1}. The CO cloud in the direction of this source has a velocity of +49 km s^{-1}.

i) 14.17−0.06

We have measured an improved position for this source which was found by Batchelor *et al.* (1980). This is the only known H_2O maser in the region which is not near a far-IR source. It is located in a region of complex, extended, radio continuum emission, but with no compact radio peak. If the undetected far-IR source is compact (diameter < 1′), the balloon telescope could have failed to detect it if its 70 μm flux density were less than 400 Jy (S81). Since the source is close to the plane and has an H_2O velocity centroid of 45 km s^{-1}, it is most likely at a distance of 4–5 kpc. At a distance of 4.5 kpc, a 400 Jy 70 μm source has a luminosity $L_{\text{far-IR}} = 2\times10^4\ L_\odot$. This is within the range of the source luminosities for the far-IR sources with detected H_2O masers.

j) 14.60+0.02

The single line seen toward this source in 1976 November was at +31 km s^{-1} (GD77). The line was at 20 km s^{-1} in 1979 November. The CO cloud in the direction of this source is at 40 km s^{-1}. A near-IR source has been detected by Moorwood and Salinari (1981).

k) 15.02−0.67(M17 SW)

GD77 detected H_2O maser emission from three separate locations near the peak of this source. We have detected emission from an additional position [15.034−0.666(4)], approximately 30″ northwest of source 3. Sources 2 and 3 are close to the compact near-infrared source M17 IRc2 (Harper *et al.* 1976). The single-line source 15.04−0.67(3), which had a velocity of −27 km s^{-1} in 1976 November, had a velocity of −42 km s^{-1} in 1980 April. Figure 3 shows the positions of the maser sources 15.02−0.67(2), (3) and (4) (*simple crosses*) superposed on contours from a 5 GHz VLA map of the region. (Churchwell 1980, personal communication). There is a compact radio source at the position of IRc2. This source has a flux density of 28 mJy at 5 GHz and 118 mJy at 15 GHz (Felli, Johnson, and Churchwell 1980). GD77 and Wilson *et al.* (1979) present schematic views of a larger area which includes this region. The close positional coincidence of the compact near-infrared source and the peak of the radio continuum emission implies that the same star may be responsible for both the ionization and the heating of the dust. Genzel and Downes (1977*b*, 1979) suggest that each "center of H_2O activity" consisting of maser emission spots concentrated within a region of $\sim10^{16}$ cm diameter (Genzel *et al.* 1978), may represent the envelope of a newly formed OB star. If this is true of the H_2O activity centers near the radio continuum peak in M17 SW (Fig. 3), then this group of masers, together with M17 IRc2, may represent a second cluster of OB stars in the M17 region. Beetz *et al.* (1976) reported a cluster of OB stars, visible in the photographic infrared, ~1′.7 NE of IRc2. Since it was possible to observe the cluster at 800 nm, it must be less heavily obscured than IRc2 and any possible stars associated with the H_2O masers. Hence there may be small, recently formed star clusters of slightly different ages within M17.

l) 15.20−0.63

Cesarsky *et al.* (1978) reported an H_2O maser near this source. The source they saw in 1977 February had a velocity of 20 km s^{-1} and a position 63″±16″ southwest

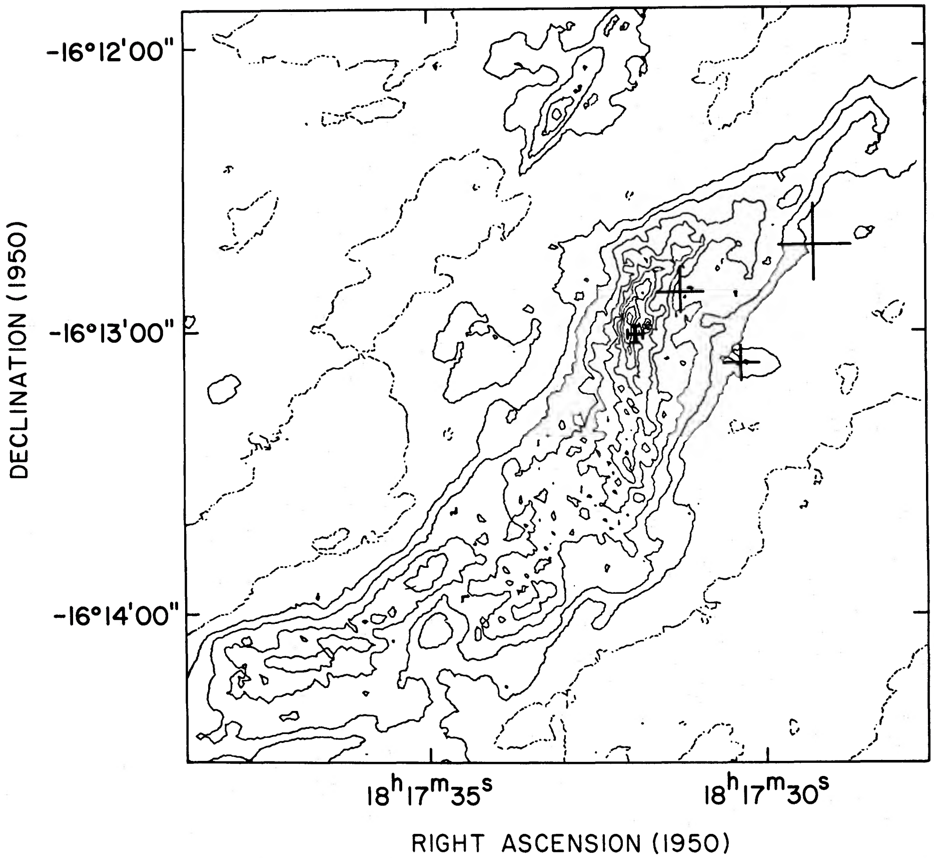

FIG. 3.—The environs of the H_2O masers M17(2-4). The plain crosses show the positions and 1 σ errors for the H_2O masers M17(2-4). The barred cross indicates the position of the near-infrared source M17 IRc2 (Harper *et al.* 1976). The contours in the figure are 6 cm continuum brightness temperature (Churchwell, personal communication). Note the "arc" and the point source near IRc2 (Felli, Johnston, and Churchwell 1980).

of the position reported here. Our source has a weak line at 20 km s^{-1} and a stronger feature at 46.5 km s^{-1}. At a position ~20″ from the Cesarsky *et al.* position and ~30″ from our own position, we see only emission from the maser at our position at a level appropriate for a source that far from the center of the main beam. Downes and Genzel (personal communication) did not detect the Cesarsky *et al.* source during observations in 1977 and 1978; the source may be variable, but it is also possible that the Cesarsky *et al.* position was in error due to sidelobe problems.

V. DISCUSSION

a) *Frequency of Occurrence*

Observers have generally searched for H_2O maser emission toward regions suspected to contain newly formed, massive stars. These searches indicate that H_2O maser emission accompanies many "signposts of star formation" such as compact H II regions (GD77; Genzel and Downes 1979), Sharpless H II regions (Lo, Burke, and Haschick 1975; Blair, Davis, and Dickinson 1978), Herbig-Haro objects (Rodriguez *et al.* 1980), and OB associations (Blitz and Lada 1978), with frequencies ranging from 5 to 15%. The most comprehensive work (Genzel and Downes 1979) indicates that there are H_2O masers with fluxes greater than 15 Jy within 30″ of ~12% of the continuum peaks of all galactic H II regions in the survey of Altenhoff *et al.* (1978). We have detected H_2O maser emission toward 50% of the far-IR survey sources. Two observations lead us to believe that the total number of far-IR sources with H_2O maser emission at some level is even higher and possibly consistent with a 100% coincidence rate: (1) the highly variable intensity of the weak H_2O sources, and (2) the distance of the detected and undetected sources.

i) *Variability*

Many observers have noted significant variations in the intensity of H_2O masers in regions of star formation over periods of months (e.g., Little, White, and Riley (1977)). The typical intensity variation in the strongest maser component for the sources we observed in 1979 November and 1980 April was a factor of 2. Many of the 22 far-IR sources toward which we detected no H_2O emission may have such emission at levels above our sensitivity limit *at some time*.

ii) *Distance Distribution*

If we adopt the kinematic distances of the CO clouds as the distances of the far-IR sources, then 60% of the far-IR sources in the sample with $d \leq 2.3$ kpc have H_2O masers, while only 7% of the far-IR sources at greater distances have H_2O masers. This indicates that the H_2O sample is sensitivity limited, and hence that nearly all of the far-IR sources may be associated with H_2O masers.

Fifty-six radio continuum sources are listed by Altenhoff *et al.* within the far-IR survey region. Of these, 23 are far-IR sources in the JSF survey. Ten of these 23 radio/far-IR sources have associated H_2O maser emission. GD77 searched toward the peaks of 25 of the remaining 33 radio continuum sources in the region and failed to find any maser sources. GD77 may have missed a few associated H_2O masers because they only made five point maps around the radio continuum peaks. The difference between associated H_2O masers toward 10 out of 23 of the radio/far-IR sources we examined and 0 out of 25 for the non–far-IR sources examined by GD77 is large enough, however, to suggest that radio continuum sources without strong far-IR counterparts are unlikely to have associated H_2O maser emission.

b) *Relation of far-IR and* H_2O *Luminosity*

Genzel and Downes (1979) found a rough correlation between H_2O maser luminosity and stellar luminosity. They selected a sample of infrared sources with associated H_2O masers where they were reasonably certain that the infrared luminosity might be directly associated with, or at least representative of, the luminosity of the IR source associated with the maser source. This sample implies that H_2O sources with luminosities $\sim 10^{-4}\ L_\odot$ arise around or near stars with luminosities $\sim 10^5\ L_\odot$, while sources with H_2O luminosities $\sim 10^{-5}\ L_\odot$ have bolometric luminosities $\sim 10^4\ L_\odot$.

We do not know the positions of the far-IR sources or the nature of their exciting stars well enough, however, to compare directly our source list with the sources cited by Genzel and Downes (1979). Higher resolution far-IR observations and more sensitive near-infrared measurements will be needed before this comparison can be made.

c) *"High Velocity" Sources*

There are H_2O emission features separated by more than 10 km s^{-1} from the CO velocity in the direction of 70% of the far-IR sources with associated H_2O masers. These features probably indicate outflow from the newly formed stars (e.g., the evidence provided by Genzel *et al.* 1981*a*, *b*). These far-IR objects are therefore probably *not* protostars in a phase of pure contraction. As has also been suggested by an increasing number of non-maser molecular measurements, this supersonic outflow of molecular gas seems to be a common feature of regions containing newly formed OB stars.

d) *Lifetime of the Maser Phase*

Genzel and Downes (1979) use two methods to estimate the duration of the maser phase in regions containing massive, newly formed stars. They derive a value of 7 to 9×10^4 yr, assuming that most H_2O masers are within $\sim 10^{18}$ cm of the peaks of radio continuum sources. The present observations suggest that including H_2O masers near far-IR sources will significantly increase the maser population. By mapping around the peaks of radio sources and including lumininious far-IR sources not visible at radio wavelengths, we have discovered maser emission toward half of the far-IR sources in our sample. If we adopt the same H_2O luminosity threshold as Genzel and Downes (1979), and if we make the somewhat naive assumption that the relative number of far-IR and radio continuum sources at the detection limits of the Altenhoff *et al.* (1978) radio survey and the JSF–S82 far-IR survey is the same over the whole galactic plane, then our results would *raise* the lifetime estimated by Genzel and Downes (1979) by at least a factor of 2, to a value of 2×10^5 yr. If the less luminous far-IR sources have lifetimes substantially longer than 2×10^5 yr (Jaffe and Fazio 1981), the H_2O lifetime could be even longer. Genzel and Downes (1979) have already discussed the difficulty of reconciling lifetimes as long as this with current models of the formation of protostars and compact H II regions. Thus while the velocity evidence (Genzel *et al.* 1981*a*, *b*) implies that the H_2O sources cannot be contracting protostars, our source statistics also indicate that the objects most likely do not belong to the phase of rapid creation of a compact H II region as envisaged in most models [Reid *et al.* 1980 makes this point for the OH maser emission from W3 (OH)]. It thus appears that there is an important mass-loss phase which has been missing from many protostar discussions to date. Future models of star formation regions must be able to account for the lengthy duration of the H_2O maser phase.

e) *Conclusions*

1. The present results are consistent with a 50–100% coincidence of H_2O masers with compact far-IR sources.

2. Compact radio H II *regions* associated with H_2O *masers* are also *far-IR* sources within the limits of the JSF–S82 far-IR survey.

3. The large velocity differences between the H_2O features and the molecular clouds in the directions of

these sources are similar to those observed in Orion. This suggests that supersonic outflow of molecular material is a common phenomenon, and that the far-IR sources are not protostars in a phase of pure contraction.

4. The source statistics tend to confirm, and even raise, the Genzel and Downes (1979) estimate of 10^5 yr for the lifetime of the maser (mass loss) phase of these objects.

We would like to thank R. Genzel and J. Moran for helpful discussions, E. Churchwell, G. Fazio, and M. Stier for providing us with data prior to publication, and A. Downes for help with the observations.

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D. DOWNES: Institut de Radio Astronomie Millimétrique, B. P. 391, 38017 Grenoble, France

R. GÜSTEN: Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 5300 Bonn 1, Federal Republic of Germany

D. T. JAFFE: Enrico Fermi Institute, University of Chicago, 5630 South Ellis Avenue, Chicago, IL 60637