Infrared Emission from the OH/H$_2$O Sources in W49

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Infrared sources have been found coincident with both sources of maser emission in W49. The ratios of their 1.35-cm H$_2$O line to 20-μm continuum emission, however, differ by a factor of 10$^3$, the notoriously powerful H$_2$O source having comparatively weak 20-μm emission. If the OH and H$_2$O masers are the result of infrared pumping, there must be some absorption of the infrared energy between the masering region and the sun. The extinction in the direction of W49 is at least 50 visual magnitudes.

INTRODUCTION

The optically-unidentified radio source W49A is one of the most luminous H II regions in the Galaxy. It is at galactic longitude 43° and is estimated to be 14 kpc distant from the sun (Mezger and Höglund 1967). It contains two powerful sources of H$_2$O maser emission, 2 arc min apart, each of which is coincident within experimental error with an OH maser source and a compact H II condensation. One of the H$_2$O sources, hereinafter called source 1, is intrinsically by far the most powerful maser source in the Galaxy, radiating some 10$^{-1} L_\odot$ in the 1.35-cm H$_2$O line (Buhl et al. 1969).

The observations described in this paper were made to investigate the relationship between maser sources and infrared emission in H II regions, and to compare the infrared emission from W49 with that from other less distant H II regions, such as W3 (Wynn-Williams et al. 1972, hereinafter referred to as WBN).

OBSERVATIONS

Observations at the wavelengths 1.65, 2.2, 4.8, 10 and 20 μm were made during 1972 March and 1972 October on the 200-in Hale telescope, using the procedures described by WBN. Measurements were confined to two sources which were discovered in the immediate vicinity of the maser sources; mapping of the infrared emission from the whole radio source, 4 arc min in diameter, was not attempted. The positions of the infrared and maser sources, and of the associated H II condensations, are given in Table 1. In both cases the maser, infrared, and radio continuum sources coincide within experimental error. Both infrared sources appear to be smaller than 10 arc sec in diameter.

The flux densities of the two sources, measured with an aperture of 7 arc sec diameter, are shown in Figure 1 together with those of W3(OH)/IRS8, another region where radio, infrared, OH, and H$_2$O emission regions coincide (WBN).

DISCUSSION

The most interesting result of the present observations is that although qualitatively the three sources in Figure 1 resemble each other in (a) having close positional agreement between radio, infrared, and maser sources and (b) showing a 20-μm excess and a 2-μm deficit compared with the extrapolated free-free radio spectrum, quantitatively there is a very wide range in the relative intensities of the maser lines and of the infrared and radio continua. For example, in W49 the ratio of the continuum at 20 μm to that at 5 GHz is ten times greater for source 2 than source 1, whereas the ratio of the continuum at 20 μm to the H$_2$O line at 1.35 cm is 10$^3$ times greater for source 2 than for source 1. Furthermore, although both sources in W49 have approximately the same intrinsic diameter (~ 0.5 pc) as W3(A)/IRS1, another H II condensation studied by WBN, source 1, in particular, differs from W3(A)/IRS1 in having twice its radio flux but only one-tenth of its 20-μm flux. Such a difference in the infrared radiation cannot be accounted for by a variation in the number or luminosity of the exciting stars within the H II regions, but rather
indicates that there must be significant variations in either the concentration, composition, or distribution of the dust in the source.

Because of the possibility that the H$_2$O masers in W49 are pumped by continuum infrared emission, it is useful to compare the photon emission rates per unit fractional bandwidth at the maser-line and the continuum infrared frequencies. Since the photon rate is proportional to flux density, it may be concluded for all the sources in Figure 1 that the photon emission rates in the H$_2$O and OH lines are greater than those in any corresponding continuum band at any infrared wavelength shortward of 20μm. A further comparison may be made for longer wavelengths for source 1 by noting that the total 100-μm flux density of W49A is 8 × 10$^{-22}$ W m$^{-2}$ Hz$^{-1}$ (Hoffman et al. 1971), approximately equal to the flux density in the H$_2$O line in source 1. However, only a small fraction of this 100-μm flux can be physically associated with the masering
region, since the latter only has a diameter of about 2 arc sec (Johnston et al. 1971); for a flux density of $8 \times 10^{-22}$ W m$^{-2}$ Hz$^{-1}$ to be emitted from a region of 2 arc sec diameter at 100 $\mu$m would require a brightness temperature of 4000 K, far greater than the color temperature of 70 K (Harper and Low 1971). It is therefore safe to conclude, for this source, that at no continuum wavelength does the continuum photon flux per unit fractional bandwidth exceed that in the H$_2$O line. Thus infrared pumping of the H$_2$O maser can be occurring only if there is anisotropic emission, or if there is absorption of the infrared radiation outside the masering region. This situation is in contrast to that in the 1612-MHz OH/IR stars, for which Hyland et al. (1972) showed that infrared pumping of the OH maser is energetically possible.

In the case of source 2, it is possible to use the 2.2- and 1.6-$\mu$m data together with the radio data to estimate the interstellar extinction in the direction of the source. From the method employed by WBN we obtain a lower limit of 50 mag at visual wavelengths; this number is increased if there is either self-absorption at 5 GHz or emission from heated dust at 2.2 $\mu$m. An accurate estimate of the extinction in the direction of source 1 is not possible because of the proximity of confusing sources at 2 $\mu$m; however, present limits indicate that the extinction must exceed 50 visual magnitudes. There is no way of telling how much of this obscuration is local to the source but, by analogy with W3, it is likely that a significant portion of it is physically associated with the H II region.

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