SiO EMISSION FROM THE ORION NEBULA

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ABSTRACT

SiO emission in both a strong maser transition in the first excited vibrational state and in a weaker transition in the ground vibrational state both arise from the same small region in the Kleinmann-Low Nebula in Orion. Within the errors, the source position coincides with that of the infrared source IRc2.

INTRODUCTION

Radiation from the SiO molecule emanates from the Orion molecular cloud both in strong maser emission in the first excited vibrational state and, more weakly, from the ground vibrational state. SiO maser emission is generally observed only in red giant stars, and Orion is unique among molecular clouds in exhibiting this radiation. Because of this particular circumstance, it is of special interest to locate the source (or sources) of the radiation with respect to other objects in the nebula. We have used the Hat Creek Interferometer to locate the emission from both the excited and ground states in Orion.

OBSERVATIONS OF MASER EMISSION

The angular extent of the maser source is very small (Genzel et al., 1979), and we have measured its position in the v=1, J=2-1 transition at 86.2 GHz. The technique is that described by Forster et al. (1978), in which the source phase near transit is compared with that of a calibrator. East-West spacings of 150 and 300 meters were used for the right ascension determination and a North-South spacing of 180 meters was used for the declination determination. Figure 1 shows the source spectrum at the time of observation and the series of phase measurements on the source and calibrators near transit for the 150-meter East-West spacing. At this spacing, a 2π phase change corresponds to a 4 arcsecond

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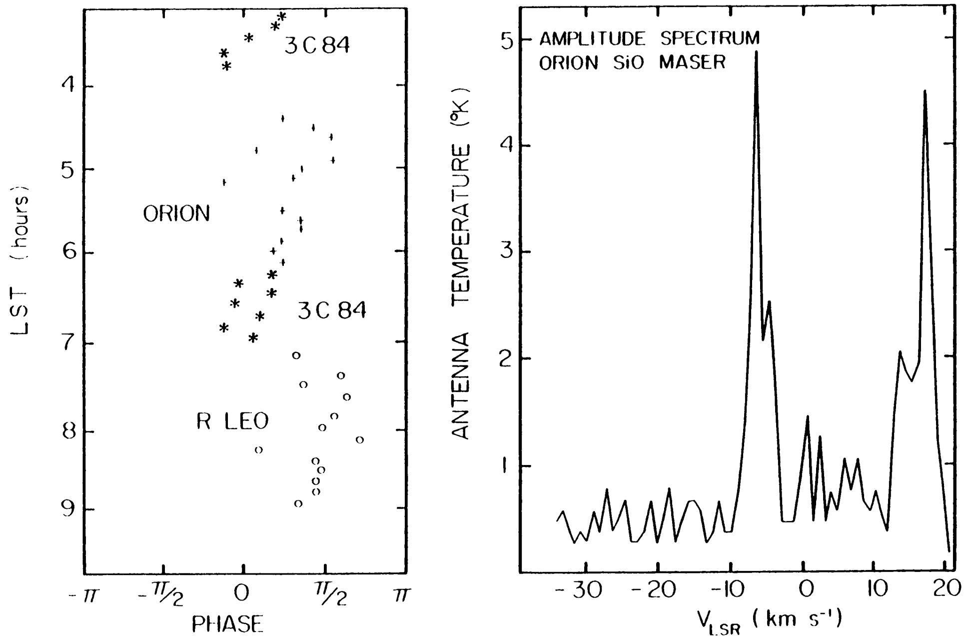

Figure 1. The Orion SiO maser at 86.243 GHz on 12 Dec 1978.

position change. The inferred source position is:

R.A.(1950) = $5^h32^m47\overset{s}{.}0 \pm 0\overset{s}{.}03$ Dec.(1950) = $-5°24'23'' \pm 1''$.

The two main features, at -6 and +16 km/sec, are coincident within $0\overset{''}{.}2$.

OBSERVATIONS OF GROUND STATE EMISSION

In the ground vibrational state, the SiO emission is much weaker and somewhat broader in spectrum than the maser. Its spectrum is more similar to the "plateau" sources seen in CO and HCN. Hence, it was included in an aperture synthesis program intended to yield maps of a 2 arcminute field of view centered on the Kleinmann-Low Nebula with an angular resolution of 10 arcseconds. The SiO was observed in the v=0, J=2-1 transition at 86.8 GHz. A preliminary inspection of the data shows that the visibility amplitude for the SiO is essentially constant out to the longest spacing,and the phase is constant and equal to that of the maser. This indicates that the emission arises in a single source which is no larger than 10" in diameter and is centered on the position of the maser. The measurements of Dickinson et al. (1976) with the 11-meter telescope are consistent with a small source at this position.

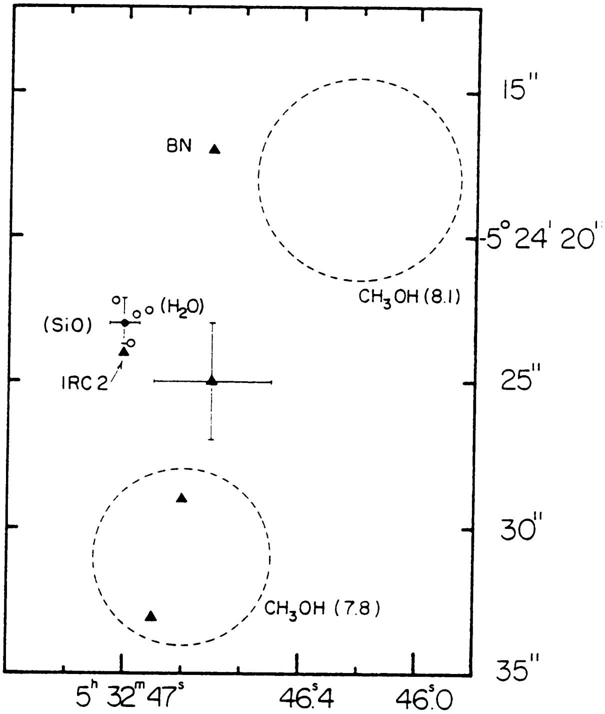

Figure 2. Position of the SiO emission in Orion.

DISCUSSION

Figure 2 shows the observed SiO position along with a number of other objects in the neighborhood of the Kleinmann-Low Nebula. The open circles are water vapor masers (Genzel et al., 1979; Forster et al., 1979) whose positional uncertainties are comparable to that of the SiO. The triangles are infrared sources (Rieke et al., 1973). Their relative positions are somewhat more accurate than their absolute placement, which is uncertain by about 2" (Rieke, 1979). The dotted circles represent methanol maser positions and approximate sizes (Matsakis, 1978). The velocities of the SiO and water vapor masers are the same, and their positions are coincident to within the errors. They also coincide with IRc2, one of the infrared objects. However, the positional uncertainties of the infrared objects are sufficiently large that coincidence with the more westerly source IRc3 is also possible, although less likely.

In all probability the emission in both the v=0 and v=1 levels arises from deep in the atmosphere of IRc2. The color temperature of this source is 335 K and its blackbody size is about 0".1 (50 a.u. at the distance of Orion). As compared with the red giant stars, the observed 8 micron and 10 micron fluxes are a little too weak for adequate radiative pumping of the SiO maser. However, the foreground dust absorption is very large, and there should be adequate flux deeper in the atmosphere of IRc2. The deep silicate absorption at 10 microns implies a foreground column density of about 3×10^{-4} g cm^2, for example. In any case, the observed 10 micron flux is adequate to pump the methanol masers, and it would be useful to determine whether there is a correlation between the time variations of the SiO and methanol fluxes. The nature of IRc2 remains obscure. Its close proximity to the other IR objects makes it unlikely that it is an evolved star like the other SiO sources. Observations with higher spatial resolution, particularly at longer infrared wavelengths, may be essential to explain its nature. This work was supported by NSF grant AST 75-13511.

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DISCUSSION FOLLOWING WELCH

Elmegreen: Can you think of any way to prove that the SiO maser in Orion is not a background late-type star?

Welch: No. The best present argument against its being a background star is the small angular separation between the maser source and the other four infrared sources in the infrared nebula. The projected separations between all these objects are only a few thousand A.U. The coincidence with a late type star seems unlikely.

Zuckerman: One way to rule out a background star would be to show that plateau emission from molecules such as SO is also associated with the source star (presumably IRC 2).

Welch: Yes, if IRC 2 turns out to be the "plateau" source, it will be distinctly different from the late-type maser stars.

Hjalmarson: I think we are all very impressed by your work. What is your position accuracy in the case of HCN?

Welch: The positional accuracy is about 1".

Winnewisser: Do you have any evidence for clumping in HCN in Orion? Over which area did you map HCN and what are the typical values for the brightness temperature?

Welch: Yes, visibility amplitudes at various baselines that we have used show that there is structure in HCN at scales between 1" and 10". At this point we do not know whether there is one clump or several. The field of view is about 2 arc minutes centered on IRC 2. HCN at scales between 1" and 10" would have to have brightness temperatures in excess of 100K.