VLBI Mapping of 43 GHz SiO Emission Associated with IRc2 in Orion-KL

L. J. Greenhill, Center for Astrophysics, Cambridge, MA
J. M. Moran, Center for Astrophysics, Cambridge, MA
M. J. Reid, Center for Astrophysics, Cambridge, MA
C. R. Predmore, University of Massachusetts, Amherst, MA
G. C. McIntosh, University of Massachusetts, Amherst, MA
A. E. E. Rogers, Haystack Observatory, Westford, MA

1. INTRODUCTION

Information on the structure of the molecular flow within 1″of IRC-2, in Orion-KL, is sparse. Measurements of the continuum at 7.8μ and 12.5μ show a disk of size 1.″1 x 1.″9 and suggest that the center of the disk may be dust free (Lester *et al.* 1985). Aperture synthesis mapping of water maser shell features (Sylber 1986) has provided information on the 0.″1 scale. Smaller scales (0.″01) can be studied by mapping SiO maser emission. We observed the 43 GHz, v=1, J=1→0, transition of SiO using a 2 station interferometer with a 74 km baseline between Haystack Observatory, Westford, MA and Five College Radio Observatory, New Salem, MA. The fringe spacing was 20 milliarcseconds (mas) and the velocity resolution was 0.25 km-s^{-1}. Our results provide the highest resolution view to date of what is likely to be the inner 0.″1 of IRC-2.

2. RESULTS

The spectrum of the maser emission at the epoch of the experiment was double peaked, as it has been since at least 1974 (Snyder and Buhl 1974; Genzel *et al.* 1979; Lane 1982). Maps were obtained by fitting, for each velocity channel, the relative phase with respect to the reference feature. The map in Figure 1. shows the most significant groupings of features. The 1σ error bars are typically < 2 mas in R.A. and < 6 mas in declination, and include contributions from systematic errors. The systematic errors probably result from residual phase slopes across the bandpasses, which could not be entirely removed in the data reduction.

The map shows seven clumps of maser features, organized in three spatially distinct centers of maser activity in the radial velocity interval $V_{lsr} = -9.5$ to 21.5 km-s^{-1}. All the maser emission originates within an area of radius ≈ 80 mas (40 AU at a distance of 480 pc). The clustering of clumps of different radial velocities within the centers of activity is neither a consequence of the Zeeman Effect, for magnetic fields <1000 G, nor of hyperfine splitting.

The linear sizes of the maser regions were estimated from analysis of the normalized fringe visbilities of the individual maser features. Most maser features have sizes of ≈ 2 to 10 mas (≈ 1 to 5 AU). The implied brightness temperatures are ≈ 10^9 to 10^{10} K, and the masers are probably at least partially saturated.

3. DISCUSSION

A current model of IRC-2 (Genzel 1985) includes an expanding torus around a compact source. The apparent major axis of the torus is tilted ≈60° east of north, and the torus is inclined to the

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line of sight (Vogel *et al.* 1985). Inside the torus, expansion at ≈ 20 km-s^{-1} is the dominant motion (Plambeck *et al.* 1982). The H_2O masers that were mapped by Genzel *et al.* (1981) are in the outer edge of the expanding torus, located perhaps where it collides with the quiescent molecular cloud. The H_2O shell masers (Sylber 1986) are located toward the inner edge of the torus.

Our results may agree with this model of IRC-2, locating the SiO masers inside the torus, close to the central compact object. However, the absolute positions of the infrared continuum, radio continuum, and 86 GHz SiO masers are not well enough established to confirm the model (Lester *et al.* 1985; Moran *et al.* 1987; Wright and Plambeck 1983). If the SiO masers are closely associated with IRC-2, one expects the central object to lie between the red and blue shifted maser groups (stellar velocity ≈ 5 km-s^{-1}). The masers would lie as close as 40 AU to the central compact object. Conservation of mass and assumptions of constant outflow velocity (18 km-s^{-1}), uniform mass loss (10^{-3} $M_\odot$-yr^{-1}), and spherical symmetry, close into IRC-2, would imply a density, at the positions of the maser groups of 5×10^9 cm^{-3}. These physical conditions would quench the formation of a spherical HII region in IRc2. In order to explain both the observed HII region and large mass loss, it may be necessary to invoke an anisotropic model of the mass loss.

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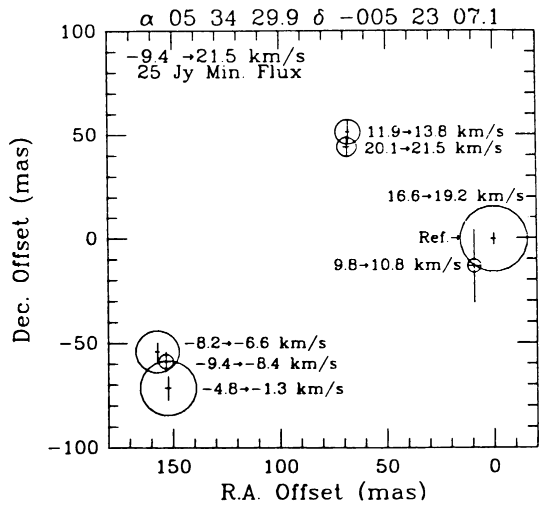

Figure 1. A simplified map of the SiO maser emission showing details of the 3 regions of maser activity. The areas of the circles are proportional to the integrated flux of the maser features. The error bars indicate the total uncertainty in position, due to formal and systematic errors.

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