A MODEL FOR THE MASER SOURCE NGC 7538 IRS 1

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ABSTRACT High resolution observations of the molecular cloud around NGC 7538 IRS 1 in the J=1-0 transition of ^{13}CO show that the lower bound for density in that region is about 2×10^3 cm^{-3}. The study of various molecular transitions and the continuum measurements of the H II region indicate that the conditions required by the Boland and de Jong model for the excitation of the H_2CO maser are not very stringent or unique.

NGC 7538 IRS 1, IRS 2, and IRS 3 is a group of infrared sources situated in a dense molecular cloud. Several molecular masers have been observed toward IRS 1, an ultracompact H II region (Campbell 1984). IRS 1 is also one of two Galactic sources where formaldehyde (H_2CO) masers have been observed. The few H_2CO masers detected (Forster *et al.* 1985; Gardner *et al.* 1986) could be due to stringent conditions required for the excitation of the H_2CO maser or because the maser emission is hidden by the more common wide absorption features of Galactic H_2CO. Boland and de Jong (1981) have modeled the H_2CO masers in NGC 7538 utilizing pumping by free-free emission from the ultracompact H II region. In order to examine the conditions required by the Boland and de Jong (1981) model, high resolution maps have been made of the J=1-0 transitions of HCN (Pratap *et al.* 1989) and HCO^+ (Pratap *et al.* 1990 - Paper I). The molecular transitions trace high density material around IRS 1 since the HCN line thermalizes at H_2 densities of about 10^6 cm^{-3} and the HCO^+ line thermalizes at H_2 densities of about 10^5 cm^{-3} (assuming that the lines are optically thin). The HCN and HCO^+ maps show the presence of a cavity in the material around the H II region (Paper I). The cavity is interpreted as being caused by lower density material in that region and thus the molecular emission surrounding the cavity implies a density enhancement in the molecular cloud. The high density tracers provide an upper bound for the H_2 density in the cavity of about 10^5 cm^{-3}. High resolution observations of ^{13}CO indicate that the lower bound for the density in the cavity is 2×10^3 cm^{-3}. The millimeter continuum fluxes from IRS 1 indicate that the H II region can be

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represented by an cool, less dense, extended component and a hot, dense, compact component.

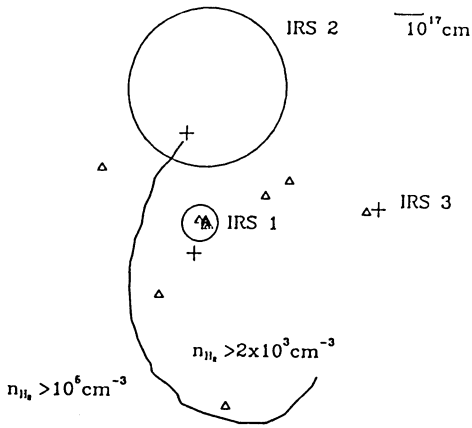

Figure 1. Front view of the molecular cloud around IRS 1, IRS 2 and IRS 3. The circles around IRS 1 and IRS 2 indicate the relative sizes of the radio continuum sources associated with them (Campbell 1984; Henkel *et al.* 1984). The crosses are the infrared positions of the three sources. The solid contour shows the edge of the high density material surrounding the low density cavity. The open triangles are positions of the H_2O masers (Kameya *et al.* 1990). All the other masers are directly in front of IRS 1.

Figure 1 shows a front view of the NGC 7538 IRS 1 region. All the masers are seen projected against the low density cavity surrounding IRS 1 and IRS 2. Calculations of the Boland and de Jong (1981) model for the H_2CO maser with the parameters obtained above show that the masers can be excited by either component of the HII region. The masering gas should be situated between 0.011 and 0.017 pc from the exciting source. The resulting fractional abundance of H_2CO with respect to H_2 should range between 2×10^{-7} and 5×10^{-8} in order to produce the observed brightness temperature for the maser. These values are consistent with the prediction of 8×10^{-7} made from chemical models (de Jong *et al.* 1980).
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