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Fine Structure of Shocked Photodissociation Regions in the Orion Bright Bar

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The Orion bright bar is a prominent ionization front located approximately $2'$ southeast of the Trapezium stars. Because this ionization front is seen almost edge-on, it provides an opportunity to study the interaction between the HII region and the adjacent molecular cloud. The molecular bar has been thought to be a narrow layer of $\sim 50''$(0.1 pc) in width parallel to the ionization front with enhanced temperature, density and column density. The molecular gas outside the ionization front was redshifted with respect to the ambient molecular cloud by 1-2 $\mathrm{kms^{-1}}$ (Omodaka *et al.* 1984, 1986, 1992), suggesting that the expanding HII region generated by the Trapezium stars had driven a shock wave into the molecular cloud at the southeast of the bar. This layer is exposed to intense UV radiation from the Trapezium stars, resulting in the formation of photodissociated regions.

We have made aperture synthesis observations of CS(J=1-0) line and 49 GHz continuum in the Orion bright bar with the Nobeyama Millimeter Array. Figure 1, a map of integrated intensities of CS, clearly revealed fine structures of the molecular bar and more than six prominent features are confirmed. It is noted that these features are lined up at $30''$ from the ionization front inside the molecular cloud.

A thermally excited H_2 line emission spectrum was observed toward the molecular bar and peaks $15''$ away from the ionization front (Hayashi *et al.* 1985), corresponding to the edge on the ionization front's side of the above-noted CS features. The spatial distribution of the 3.3 μm emission, which is believed to have arisen from regions exposed to strong UV radiation, across the bar has a maximum between the ionization front and the H_2 peak (Sellgren, Tokunaga, and Nakada, 1990). Sellgren, Tokunaga, and Nagata (1990) argued that the intensity decrease of the 3.3 μm feature at the H_2 peak can be understood if the incident UV radiation reaches the optical depth of 1 at $10''$–$15''$ inside the molecular cloud. This condition is satisfied if the molecular gas is highly clumpy so that the less dense gas with density $n(H_2) \sim 10^4\,\mathrm{cm^{-3}}$ exists together with denser gas with $n(H_2) > 10^5\,\mathrm{cm^{-3}}$. For such a clumpy condition to occur in the molecular bar, UV radiation penetrates deep into the molecular bar, and the dense clumps between

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the ionization front and the H_2 peak are heated by intense UV radiation with gas temperature exceeding 1000 K (Sternberg and Dargarno, 1989), and expand into the ambient low density gas. Then, the thermal H_2 emission 15″ away from the ionization front might arise from the surface of the dense feature discovered by this interferometer observations which is heated by UV radiation, as has been suggested by theoretical calculations (Sternberg and Dargarno, 1989).

Reference

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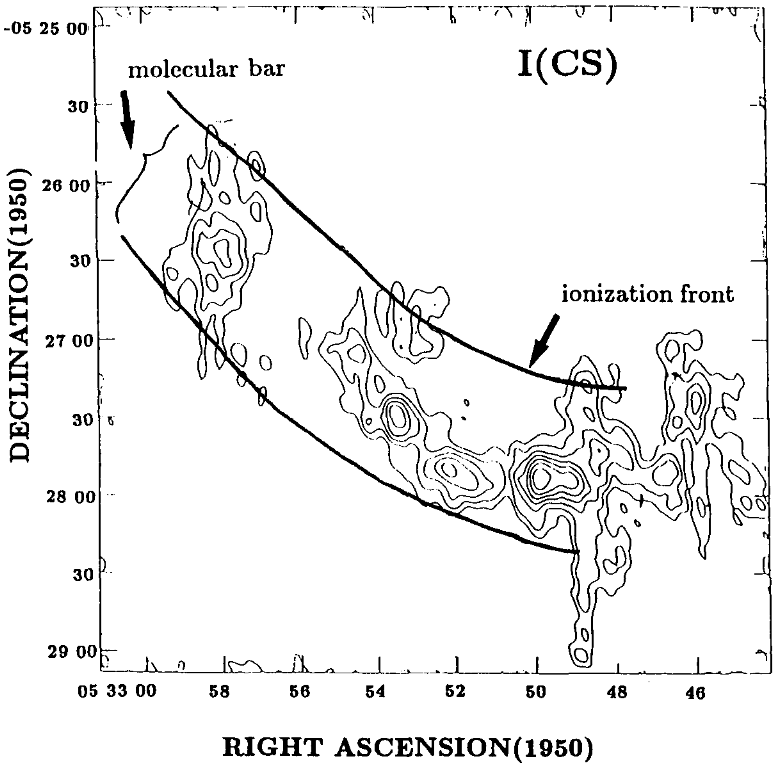

Fig. 1. Total intensity map of the CS(J=1-0) emission integrated over a velocity range of 7.7 to 12 kms^{-1} by the NMA with a synthesized beam of 10.0″ × 8.3″. The lowest contour is 1.1 × 10^{-1}Jy/Beam and the contours are spaced by 1.1 × 10^{-1}Jy/Beam. Heavy line shows the ionization front. Molecular bar is a layer with its velocity of 1-2 kms^{-1} redshifted with respect to the ambient cloud.

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