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We carried out radio, near-infrared, and optical observations of an IRAS point source IRAS 19550+3248. The source is located at the center of a small(4' x 7')molecular clump, which is at the end of a long($\sim1°$)filamentary molecular cloud. ^{12}CO J=1-0 line observations revealed high-velocity(HV) molecular outflow centered at IRAS 19550+3248. The IIV gas has a bipolar pattern with the blue and red peaks separated by 1' along the north-south direction. The mechanical luminosity of the HV molecular outflow is ~6 x $10^{31}d_2$ erg s-1 , and its dynamical age is $\sim$ 5 x 10^4d_2 yr, where d_2 is the distance to the source normalized by 2kpc.

Inside the 95% confidence ellipse of IRAS position, we detected a point source with nebulosity in K band(see figure), which might be the protostellar object that drives the HV molecular outflow. The nebulosity extends to $0.1d_2$ pc (without beam deconvolution) in the east-west direction. The infrared source has a steep spectral index between 2 and 25 μm(n $\equiv$dlog(νF_ν)/dlogν=-0.93), which is typical for a protostar deeply embedded in a molecular cloud core. The bolometric luminosity based on R, I, H, and K band photometry together with IRAS data is $150d_2^2$ $L_\odot$. Similar to other HV molecula out flow sources, the radiation force of IRAS 19550+3248 is considerably, by a factor of $10d_2^{-1}$, smaller than the required mechanical force. In R and I bands, we detected two bright sources located close to the peak position in K band (see figure). We discuss the implications of our results on the physical environment near the protostellar object.

Excitation of CO Molecules in Clumpy Interstellar Clouds

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To investigate how clumpy structure of interstellar clouds affects the excitation conditions of CO molecules, we generalized the one dimensional Monte Carlo code, originally developed by Bernes(1979), to a three dimensional one. Test was made of our 3D code by reproducing all the 1D results of Bernes, who had recovered the results of Leung and Liszt(1976) by applying his 1D Monte Carlo code to the spherical cloud completely filled with matter.

A sphrical volume was first divided into $4\pi/3 \times 7^3$ cubic cells of equal size, and then some of the cells were filled with gas while others being kept empty, thereby simulating the

clumpy structure of interstellar cloud. Along with the excitation rate equations of statistical equilibrium, we have solved the problem of radiative transfer in such a model cloud of clumpy structure. Six rotational excitation levels of CO from J=0 to 5 were included in the rate equations; the kinetic temperature of H_2 molecules was fixed at 15K everywhere in the cloud; and 1km/s was adopted for the temperature were assumed to be constant. Number density n of H_2 molecules inside clumps and their volume filling factor f were taken as model parameters.

For six combinations of n and f, we calculated the excitation temperature T_{ex} for various rotational transitions of ^{12}CO molecules, and examined how the resulting excitation conditions vary with radial distance. In clumpy clouds the excitation temperature is generally higher at the cloud center than it is near the boundary. In a cloud with very small filling factor, for example f = 0.13, there is not much difference of radiation density between the center and boundary. When sub-clumps of a cloud occupy only very small fraction of the cloud total volume, the radiation field is essentially the same everywhere in the cloud. Consequently, the difference $\triangle T_{ex}$ in excitation temperature from the center to boundary decreases as f decreases. Even in those clouds that have the same value of n x f, the excitation conditions are quite different from each other, depending on n and f. For a fixed n, the excitation temperatures in clumpy clouds (f less than unity) are substantially lower than they are in a completely filled one (f=1); they generally decrease with decreasing volume filling factor. When f is fixed, T_{ex} varies significantly with the internal density of clump. However, radial gradient in the variation of T_{ex} doesn't change much with n; it is the volume filling factor that controls the radial gradient of T_{ex}.

We will do the same type of calculations for the transitions of ^{13}CO and discuss the roles of optial depth in the formation of molecular lines in clumpy clouds.

THE CO STUDY OF GIANT MOLECULAR CLOUD
TOWARD SUPERNOVA REMNANT CTB 87

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The giant molecular cloud toward supernova remnant CTB 87 has been observed in the J=1-0 transitions of CO and ^{13}CO. The CO integrated intensity maps show three clumps with each sub-structure. The two subclumps of clump A are located at the boundary of