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PERVASIVE SMALL-SCALE STRUCTURE IN MOLECULAR CLOUDS

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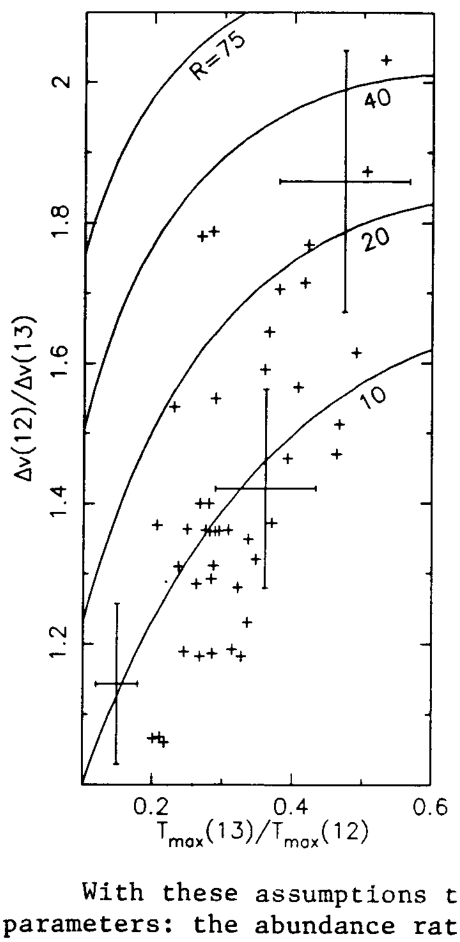
We have completed an unbiased CO survey of molecular cloud cores, and analyzed the profiles within the context of a model for emission from clumpy clouds. We find that all sources observed contain a significant amount of structure that is not resolved with our 2.3-arcmin beam, and that the parameters which describe the degree of clumping span a remarkably narrow range of the possible values.

We studied two separate samples of cloud cores: a large sample of warm cores comprising the 91 brightest points from the Massachusetts-Stony Brook 12CO survey of the first galactic quadrant (Sanders et al., 1986), and a sample of cool cores made up of 19 positions in the Taurus dark clouds chosen primarily on the basis of H2CO emission. We observed all sources in the 1-0 transition of 12CO and 13CO with the 5-m telescope of the Millimeter Wave Observatory, obtaining spectra with 0.65 and 0.16 km/s resolution.

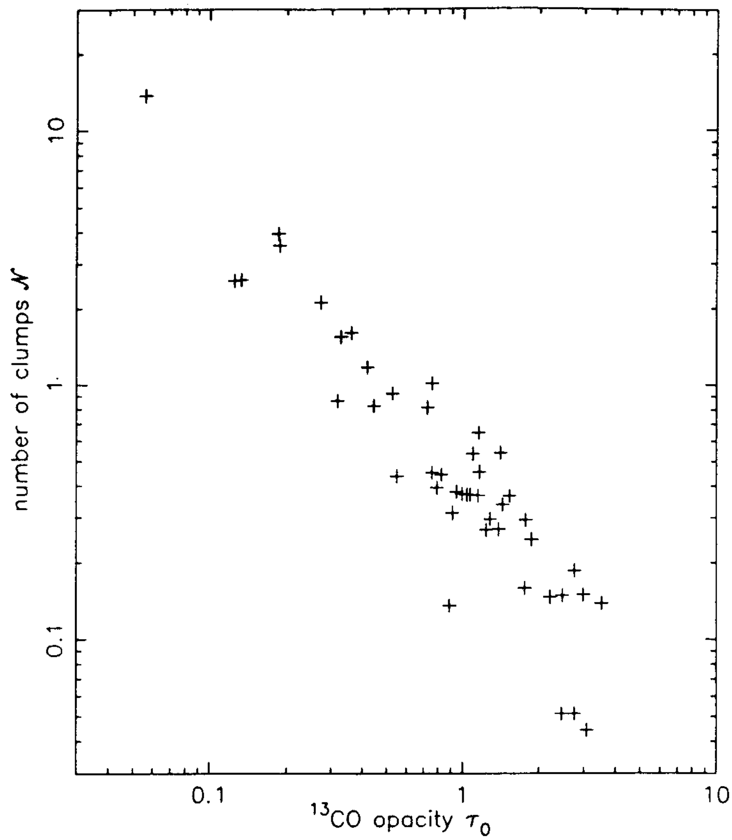


The first figure shows the ratio of peak intensities and ratio of linewidths between the two isotopes, for the sample of warm cores. Only about half of the sources are shown here, those with relatively simple profiles for which we could determine intensities and linewidths more accurately. Also shown are some representative error bars, and curves representing the predictions of a uniform-density microturbulent model for different values of the 12CO-to-13CO abundance ratio. For reasonable values of the abundance ratio (R≅75), this model predicts tremendous saturation-broadening of 12CO profiles, but most sources show only moderate enhancement of the 12CO linewidth.

These ratios can be explained if there is unresolved structure giving rise to significant variations of opacity across the beam. Our model cloud consists of a large number of identical clumps distributed randomly in the beam. These clumps have velocity widths v small compared to the width of the observed profile, which is determined by the relative motion of the clumps. The entire cloud is isothermal and in LTE.

With these assumptions the intensity and linewidth ratios depend on three parameters: the abundance ratio; the peak 13CO opacity through a single clump, τ_0; and the average number of clumps on a line of sight (counting only those clumps in a velocity range v at the line center), N. Small τ_0 and large N

(lots of transparent clumps on each line of sight) correspond to the microturbulent limit, which is indistinguishable from a uniform gas distribution. In the other extreme, large τ_0 and small N, at a given velocity at most one clump contributes to the profile on each line of sight. Since each clump is opaque even in 13CO, the profile is determined largely by a variation of filling factor with velocity, and profiles tend to be similar in the two isotopes. The observed sources span the range between these two limits, but nearly all require a considerable amount of unresolved structure to explain their intensity and linewidth ratios.



The second figure shows the model parameters which reproduce the measured intensity and linewidth ratios for the sample of warm cores, assuming an abundance ratio of 75. The sources in the upper left are close to the microturbulent limit, while those to the lower right have the most clumpy structure. The distribution of sources in the N-τ_0 plane is very similar for the cool cores.

A striking tendency toward constant $N\tau_0$ is present. The warm cores (left) obey the relation

$$\log N = (-0.41\pm0.03) - (1.16\pm0.07)\log \tau_0,$$

while the cool cores (right) follow

$$\log N = (-0.03\pm0.03) - (0.97\pm0.06)\log \tau_0.$$

The boundary along the lower left of each distribution may represent an opacity or column density threshold for the formation of a dense core, while that along the upper right may correspond to a threshold for massive star formation (in the case of the cool cores, for any star formation) resulting in disruption of the core.

REFERENCES

Martin, H. M., Sanders, D. B., and Hills, R. E. 1984, MNRAS, 208, 35.

Sanders, D. B., Clemens, D. C., Scoville, N. Z., and Solomon, P. M. 1986, Ap. J. Supp., 60, 1.