AMMONIA OBSERVATIONS OF THE MOLECULAR CLOUDS NEAR S68, S140 AND OMC2

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Maps of the J=1,K=1 inversion transition of interstellar ammonia are presented and compared with observations of carbon monoxide and formaldehyde.

Recent estimates of the densities within molecular clouds derived from CO observations (Plambeck and Williams, 1979) yield results which are often 10 to 100 times less than those deduced from those of 2mm. H_2CO (Wootten et al., 1978). To shed light on this disagreement we present here maps of the cloud cores in S68, S140 and OMC2, made in the $NH_3(1,1)$ inversion doublet at 23.69 GHz with a 2.2 arc min. beam, using the SRC Appleton Laboratory 25m telescope (see figure 1). Our J=2,K=2 maps are generally similar, but limited by an inferior signal/noise ratio. The ammonia doublet is appropriate for the task, being excited at densities intermediate between those required for CO($\sim 10^3$ cm^{-3}) and 2mm. H_2CO(10^6 cm^{-3}).

For S140 and OMC2 the dimensions of the NH_3 and H_2CO emission (Blair et al., 1978, Kutner et al., 1976) are rather similar : those of ^{13}CO are noticeably more extended. For S68 the NH_3 and ^{13}CO (Blair et al., 1975) have similar dimensions : no data on H_2CO have yet been published. Near the peak of the NH_3 emission the optical depth τ of the (1,1) line has been deduced from the main/hyperfine component ratios (see, e.g., Schwartz et al., 1977) - results of order unity are obtained. The excitation temperature T_{EX} may be calculated from τ, the source dimensions, and the observed antenna temperatures, assuming that the source is not 'clumped'. The density of molecular hydrogen may then be obtained from T_{EX}, the kinetic temperature T_K (deduced from ^{12}CO observations), and τ. The derived densities $\sim 5\times 10^3$ cm^{-3} are much less than those deduced from 2mm. H_2CO although the NH_3 emission has similar dimensions. The discrepancy may be resolved by either a "core-halo", or a "clumped" structure for the sources. The latter possibility is more probable, in which case the medium is well modelled as many 'clumps' of density $\sim 10^6$ cm^{-3} and size $<5\times 10^{-2}$ pc (dominating the NH_3 and H_2CO emission) immersed in a more tenuous medium of density 10^{3-4} cm^{-3} (dominating that of CO).

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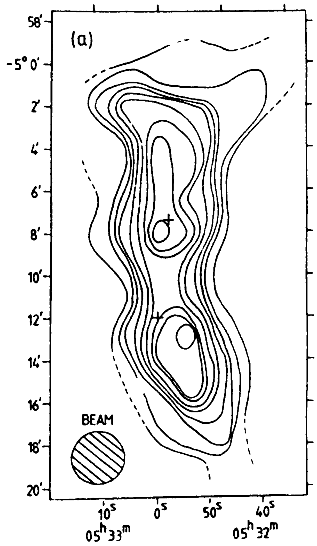

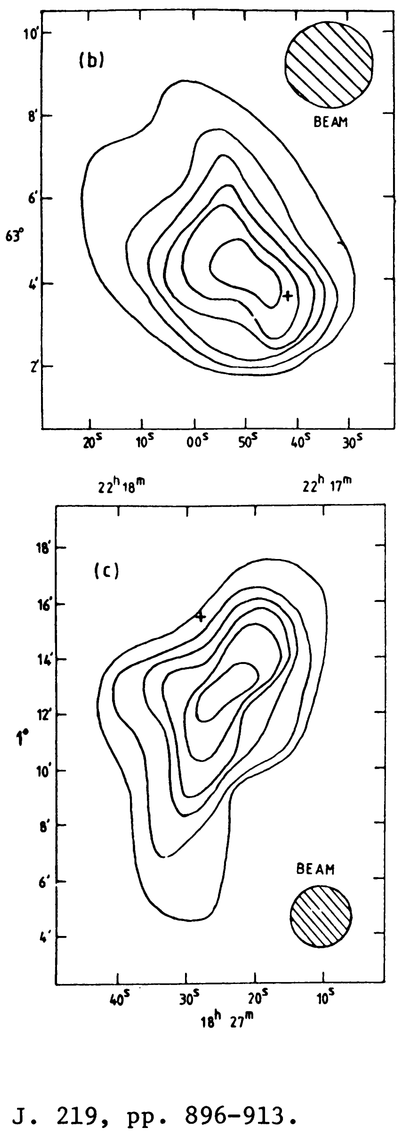

Figure 1. Maps of peak antenna temperature of the $NH_3(1,1)$ line observed with velocity resolution 0.86 km s^{-1} in (a) OMC2 (b) S140 and (c) S68. Water maser positions are marked +. The contour interval is 0.1K, the lowest contour is 0.2K.

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DISCUSSION FOLLOWING MATHESON

Scoville: It might be worthwhile including the effects of far-infrared pumping of NH_3 in your excitation calculations.

Ho: The relevance of this work to this particular session concerns the question of clumping in dark clouds. It is such an important question that great care should be paid to the interpretation of the data. Barrett and I have mapped the same clouds with greater angular and spectral resolution at Haystack. Whereas the general shapes of the emission regions are similar, we find additional structures $\lesssim 2'$ in the cloud associated with S68 (Serpens object), (Ho and Barrett, Ap. J. submitted). This means $T_{ex}(NH_3) \gtrsim 10K$, when beam dilution effects are taken into account. As $T_K \sim 20K$, $n(H_2) \sim few \times 10^4 cm^{-3}$ would account for the excitation of the NH_3 line. If $n(H_2)$ is even higher so that $T_{ex} \sim T_K$, "clumping" is still not severe in the sense that $\sim 50\%$ of the beam would be filled. We would conclude therefore that clumping with many small clumps within the antenna beam is probably incorrect for this case. In addition, mapping results in dark clouds (Ho and Martin, in preparation) reveal that individual fragments are resolved with size scales of ~ 0.1 pc. However these fragments are well isolated and correspond to optical condensations. Hence clumping, such that there are many unresolved clumps within a 2' beam, is probably not well established for cool ($\lesssim 20K$) clouds at the present time.

Matheson: We would agree with the latter comment: for example, observations of the quiescent dark clouds Taurus and Heiles 2, which have very narrow line widths, and appear to lack H_2O masers and internal infrared sources, do not indicate intrinsic filling factors differing substantially from unity (Little et al. MNRAS 1979). However for the sources I have described here, if we invoke a 'clumping' model with the ammonia excited at the kinetic temperature of the source, then from our data it is difficult to avoid the conclusion that our telescope beam remains substantially unfilled.