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HIGH ANGULAR RESOLUTION MM- AND SUBMM-OBSERVATIONS OF DENSE MOLECULAR GAS IN M82

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We have observed CO(7-6), CO(3-2), HCN(3-2) and HCO⁺(3-2) line emission toward the starburst nucleus of M82 and have obtained an upper limit to H¹³CN(3-2). These are the first observations of the CO(7-6), HCN(3-2) and HCO⁺(3-2) lines in any extragalactic source. We took the CO(7-6) spectrum in January 1988 at the IRTF with the MPE/UCB 800 GHz Heterodyne Receiver (beam 30" FWHM, Harris *et al.* 1987). In March 1989 we used the IRAM 30m telescope to observe the CO(3-2) line with the new MPE 350 GHz SIS receiver (beam 9" FWHM, Harris *et al.* 1989) and the HCN(3-2) and HCO⁺(3-2) lines with the IRAM 230 GHz SIS receiver (beam 12" FWHM, Blundell *et al.* 1988). The observational parameters are summarized in Table 1.

→ IRTF 1.3m Gas Receiver Detectors
= the Bill's MacFar Range (J.B.L.M.)

Line	Frequency	Resolution	Telescope	Receiver
CO(7-6)	806.65 GHz	30"	IRTF	MPE/UCB
CO(3-2)	354.79 GHz	9"	IRAM 30m	MPE SIS
HCN(3-2)	265.87 GHz	12"	IRAM 30m	IRAM SIS
HCO ⁺ (3-2)	267.56 GHz	12"	IRAM 30m	IRAM SIS

Table 1: Observational parameters

Fig. 1 shows spectra of the different lines for the offset position 10" (160 pc) to the SW from the nucleus.

For this position, in the vicinity of the supernova remnant 41.9+58, each of the lines shows a strong, narrow feature at $V_{LSR} \sim 110 \text{ km s}^{-1}$. The CO(7-6) emission of the nuclear region of M82 consists only of this narrow feature and no emission of the bulk of the molecular gas is seen. The CO(3-2) and HCN(3-2) emission is strongest 10" SW of the nucleus with the same feature clearly visible. It is also prominent in far-infrared emission lines (Lugten *et al.* 1986, Duffy *et al.* 1987).

Our preliminary results are summarized as follows:

We attribute the emission feature at $V_{LSR} \sim 110 \text{ km s}^{-1}$ to an unusually large star forming complex near the nucleus of M82 with dense gas and a large number

of young, massive stars ($L \sim 10^{10} L_{\odot}$). Estimates of the size and mass of this most active current star-forming region in M82 yield $5 \rightarrow 10''$ ($80 \rightarrow 160$ pc) and several $10^7 M_{\odot}$. The intrinsic strength of the CO(7-6) line then is a few 10 to 100 K. The excitation of this line as well as of HCN(3-2) and HCO⁺(3-2) requires densities $\geq 10^4 \text{ cm}^{-3}$. The close correlation between CO(7-6) emission and UV-radiation from young, massive stars in galactic sources suggests heating of the CO(7-6) emitting gas by UV-radiation or shocks. The character of this nuclear "hot spot" is not unlike that of the molecular mass concentration near the nucleus of our own galaxy. A more detailed discussion of the nuclear "hot spot" will be published elsewhere (Harris *et al.* 1989).

The HCN and HCO⁺ data for other positions show that the central 1 kpc of M82 contains a large amount of dense gas ($n(\text{H}_2) \geq \text{several } 10^4 \text{ cm}^{-3}$). The ¹²CO(3-2) line flux at all measured positions is weaker by at least a factor of 2 compared to the ¹²CO(2-1) line. We find a similarly low ratio $I(^{12}\text{CO}(3-2))/I(^{12}\text{CO}(2-1)) \leq 0.5$ also in a number of galactic molecular cloud complexes. The low ¹²CO(3-2) to (2-1) intensity ratio cannot be accounted for in simple one component models of the CO emission in molecular clouds. The low ratio may be due to a component of relatively low density ($n(\text{H}_2) \leq 10^3$) and low temperature (10 to 20 K) interclump gas where the J=3 level of ¹²CO is subthermally populated, as in the model for the CO emission of the M17 interface (Stutzki *et al.* 1988). It is then likely that the large ¹²CO(2-1) to (1-0) ratio is due to temperature gradients in predominantly externally heated clouds (see discussion in Young and Scoville 1984). A more detailed discussion will be presented in Wild *et al.* .

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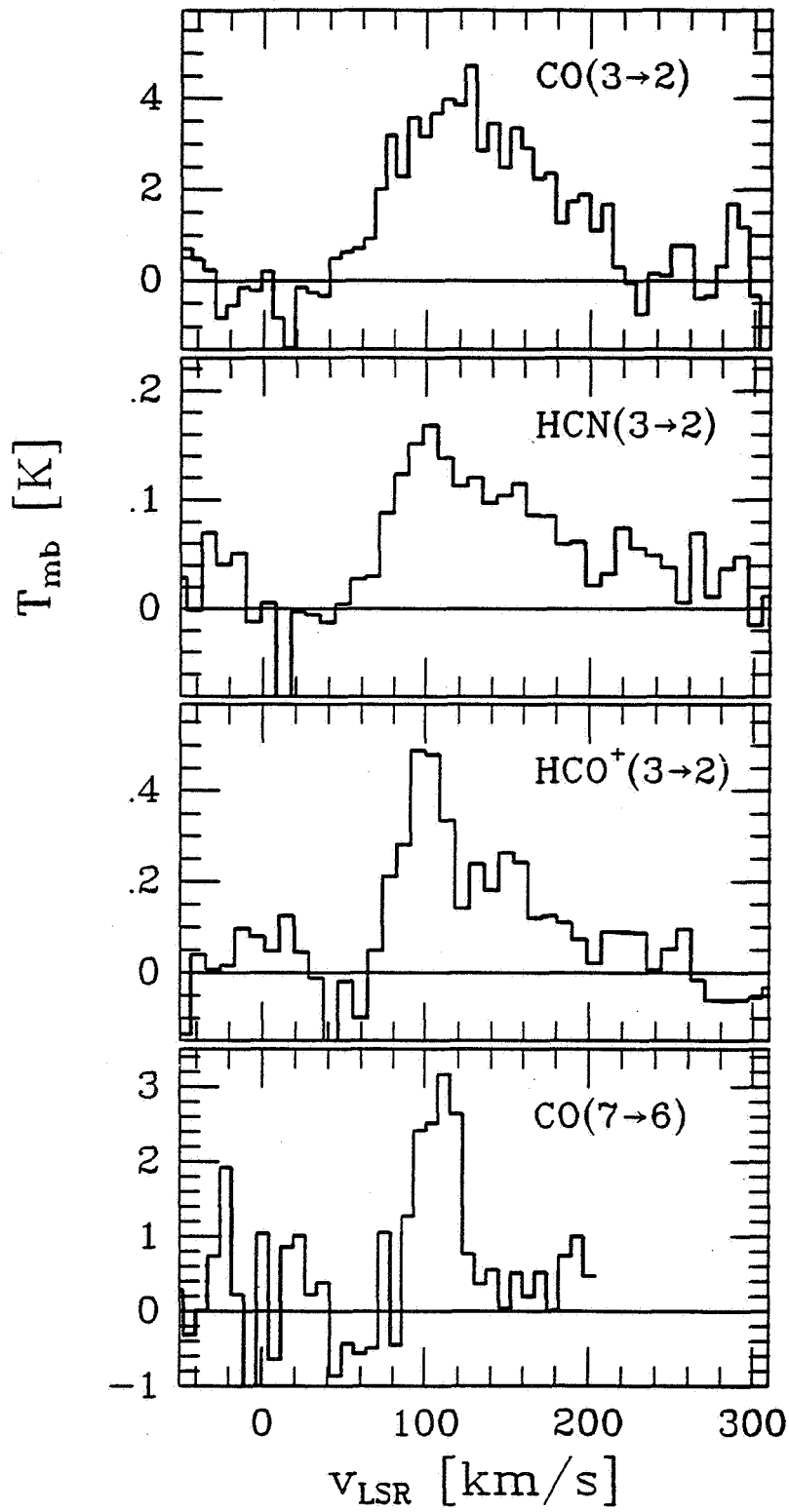


Fig. 1 Spectra of the nuclear "hot spot" of M82, 10" (160 pc) SW of the nucleus