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

W. Wild¹, A. Eckart¹, R. Genzel¹, A.I. Harris¹, J.M. Jackson¹, D.T. Jaffe², J.B. Lugten³ and J. Stutzki¹

¹ Max-Planck-Institut für extraterrestrische Physik, D-8046 Garching b. München, West Germany
² University of Texas at Austin, Austin, TX
³ Institute for Astronomy, Univ. of Hawaii, Honolulu, HI

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.

<table>
<thead>
<tr>
<th>Line</th>
<th>Frequency</th>
<th>Resolution</th>
<th>Telescope</th>
<th>Receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO(7-6)</td>
<td>806.65 GHz</td>
<td>30''</td>
<td>IRTF</td>
<td>MPE/UCB</td>
</tr>
<tr>
<td>CO(3-2)</td>
<td>354.79 GHz</td>
<td>9''</td>
<td>IRAM 30m</td>
<td>MPE SIS</td>
</tr>
<tr>
<td>HCN(3-2)</td>
<td>265.87 GHz</td>
<td>12''</td>
<td>IRAM 30m</td>
<td>IRAM SIS</td>
</tr>
<tr>
<td>HCO⁺(3-2)</td>
<td>267.56 GHz</td>
<td>12''</td>
<td>IRAM 30m</td>
<td>IRAM SIS</td>
</tr>
</tbody>
</table>

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 ~ 110 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 ~ 110 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 \(5 \rightarrow 10''\) (80–160 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 \((n(H_2) \geq \text{several } 10^4\, \text{cm}^{-3})\). The \(^{12}\text{CO}(3–2)\) line flux at all measured positions is weaker by at least a factor of 2 compared to the \(^{12}\text{CO}(2–1)\) 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 \(^{12}\text{CO}(3–2)\) 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 \((n(H_2) \leq 10^3)\) and low temperature (10 to 20 K) interclump gas where the \(J=3\) level of \(^{12}\text{CO}\) 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 \(^{12}\text{CO}(2–1)\) 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.

References


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