Introduction

Carbon isotope ratios in the interstellar medium provide an avenue for a quantitative assessment of stellar nucleosynthesis. For example, the $^{12}$C/$^{13}$C isotope ratio is also considered an important tracer of the chemical evolution of the galaxy. In order to understand the origin of the $^{12}$C/$^{13}$C isotope ratio, it is necessary to track its formation in the interstellar medium. This is because the $^{12}$C/$^{13}$C ratio reflects the relative degree of primary to secondary processing. In order to further examine $^{12}$C/$^{13}$C ratios, we have conducted observations of N=1-0 and N=2-1 transitions towards W31 (Figure 3) and S156 (Figure 4). The work is an extension of a study previously conducted by Savage et al. (2002). CN is a unique tracer of this ratio because of the high excitation temperature (300 K or more) of the molecules. In this study, we will present results from our observations and compare them with the literature.

Observations

- Observations are being made using ARO's Kitt Peak 12m. The isotopic species are assigned by the quantum number $F$.
- The frequency for the N=1-0 transition is 113490.98 MHz, and for the N=2-1 transition is 108780.2 MHz.
- Observations are being conducted towards the molecular cloud S156. This cloud is also considered an example of this data taken towards the molecular cloud S156 (Figure 4).
- Relative intensities of each hyperfine component help to directly evaluate the opacity of a given source.

Table 1: $^{12}$C/$^{13}$C Ratios derived from CN, CO and H$_2$O

<table>
<thead>
<tr>
<th>Source</th>
<th>(deg)</th>
<th>(deg)</th>
<th>$^{13}$C/H$_2$O</th>
<th>Total</th>
<th>$^{13}$C/CO</th>
<th>$^{13}$C/CN</th>
<th>AVG: $^{13}$C/CO</th>
<th>AVG: $^{13}$C/CN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SgrB2(OH)</td>
<td>-0.02</td>
<td>-0.01</td>
<td>0.01</td>
<td>4.00</td>
<td>4.25</td>
<td>4.50</td>
<td>4.10</td>
<td>4.40</td>
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<tr>
<td>G23.9</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.12</td>
<td>3.90</td>
<td>4.10</td>
<td>4.50</td>
<td>4.20</td>
<td>4.40</td>
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<tr>
<td>G29.2</td>
<td>-0.45</td>
<td>0.35</td>
<td>0.25</td>
<td>3.00</td>
<td>3.80</td>
<td>3.80</td>
<td>3.60</td>
<td>3.80</td>
</tr>
<tr>
<td>W33</td>
<td>-2.09</td>
<td>2.10</td>
<td>0.10</td>
<td>70.00</td>
<td>70.00</td>
<td>68.00</td>
<td>69.00</td>
<td>68.00</td>
</tr>
<tr>
<td>S156</td>
<td>-0.50</td>
<td>0.50</td>
<td>0.20</td>
<td>4.00</td>
<td>4.00</td>
<td>4.20</td>
<td>4.20</td>
<td>4.20</td>
</tr>
<tr>
<td>CRN 268B</td>
<td>-0.50</td>
<td>0.50</td>
<td>0.20</td>
<td>4.00</td>
<td>4.00</td>
<td>4.20</td>
<td>4.20</td>
<td>4.20</td>
</tr>
</tbody>
</table>

Results and Analysis

- New molecular clouds have been observed for the N=1-0 transitions of CN and CO.
- New results and those of Savage et al. (2002) are listed in Table 1.
- Figure 1 is an example of the data taken towards the molecular cloud S156.
- Each rotational transition of multiple isotope ratios is labeled by the quantum number $F$.
- Relative intensities of each hyperfine component help to directly evaluate the opacity of a given source.

Discussion

- Figure 1: Representative spectra of the N=1-0, 2-1/2-0 transition of CN (upper panel) at 131 K and F2=3/2-CN (lower panel) at 198 K towards the molecular cloud S156 using the ARO 12m telescope.
- The relative intensities of each hyperfine component help to directly evaluate the opacity of a given source.
- Gas Kinetic Temperature vs. CN isotope ratios (Figure 6).
- The CO isotope gradient is indicated by the black line.

References

- Coin and Peeters 2002.
- Savage et al. 2002.
- Savage et al. 2002.

Figure 1: Representative spectra of the N=1-0, 2-1/2-0 transition of CN (upper panel) at 131 K and F2=3/2-CN (lower panel) at 198 K towards the molecular cloud S156 using the ARO 12m telescope. The relative intensities of each hyperfine component help to directly evaluate the opacity of a given source.

Figure 2: Graph of the $^{13}$C isotope ratio derived from CN in a diagram of gas kinetic temperature versus CN. The black line is the theoretical prediction of carbon-13 enrichment arising from fractionation at equilibrium, for a $^{12}$C/$^{13}$C ratio of 89.