A Search for Hidden Molecular Clouds in the Milky Way

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Introduction

As galaxies are major components of the universe’s structure, it is critical to understand their internal processes, such as star formation which occurs in the coldest, densest interstellar clouds. Unlike stars, these clouds are difficult to detect in visible light, but radio and infrared telescopes allow observations of the gas and dust particles they contain. In regions of the galaxy, ambient neutral atomic hydrogen gas is forming molecules, a sign of condensing clouds. We are interested in these clouds as precursors to stellar evolution where molecular hydrogen is critical. However, it is difficult to directly observe molecular hydrogen. Thus, proxy detectors such as carbon monoxide (12CO) are used as indicators of molecular hydrogen. This method isn’t flawless. Through a comparative study, we propose that there is substantial dark molecular hydrogen not being seen with the current methods.

Methods

Initially, we identified several cold, narrow-line (a few km/s) hydrogen clouds with I-GALFA HI data in the 21 cm emission. After identification, we analyzed line properties of the feature manually considering the full-width-half-maximum, center line velocity, brightness temperature, column density, apparent size, and several other properties. These were then analyzed by a line-fitting software designed by Jonathan Newton, to model the line features. As a comparison, we utilized IRAS IRIS infrared observations to extract total cloud and dust information performing similar measurements upon this data set at positions analogous to the HI analysis. To conclude, we compared the molecular column density as indicated by the carbon monoxide analysis.

Early Results

By comparing column densities of the 21-cm atomic gas emission and the infrared dust emission, an approximation of the total molecular hydrogen column density can be computed. There is insufficient visible molecular hydrogen from the CO proxy to account for the expected total indicating a dark molecular component. This is derived from:

\[ N_{H_2}(\text{dark}) = \frac{N_{H_2}(\text{dust}) - N_{H_2}(\text{fit})}{2} \]

Future Work

We wish to modify the line-fitting model of Jonathan Newton by adjusting for biases so a more correct model of the clouds can be ascertained. This will yield more information about the relationship between optical depth, temperature, etc. and the environment in which the cloud persists. Altogether this results in a greater understanding of the environmental impacts of the ISM.

<table>
<thead>
<tr>
<th>Feature</th>
<th>(N_H(\text{simple})) cm(^{-2})</th>
<th>(N_H(\text{fit})) cm(^{-2})</th>
<th>(N_{H_2}(\text{dust})) cm(^{-2})</th>
<th>(N_{H_2}(\text{visible})) cm(^{-2})</th>
<th>(N_{H_2}(\text{dark})) cm(^{-2})</th>
<th>Optical Depth</th>
<th>Temperature</th>
<th>Brightness</th>
<th>Line-Width</th>
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<td>3.67x10(^{20})</td>
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<td>2.54x10(^{19})</td>
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| I       | 6.73x10\(^{19}\)              | 7.43x10\(^{19}\) | 1.35x10\(^{21}\) | 1.39x10\(^{20}\) | 4.97x10\(^{20}\) | 0.677926   | 31.3669   | 21.5345   | 2.1715    

References

-Koo, T. M., 2010, I-GALFA HI data from the Center for Astrophysics