Properties of Cold Galactic Interstellar Clouds

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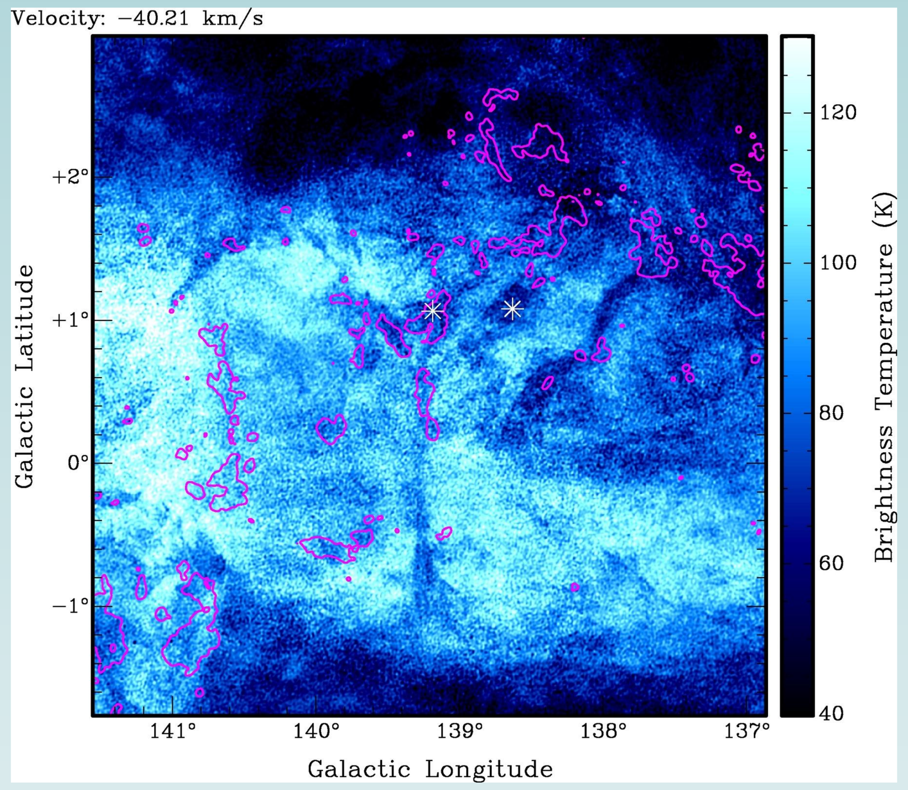
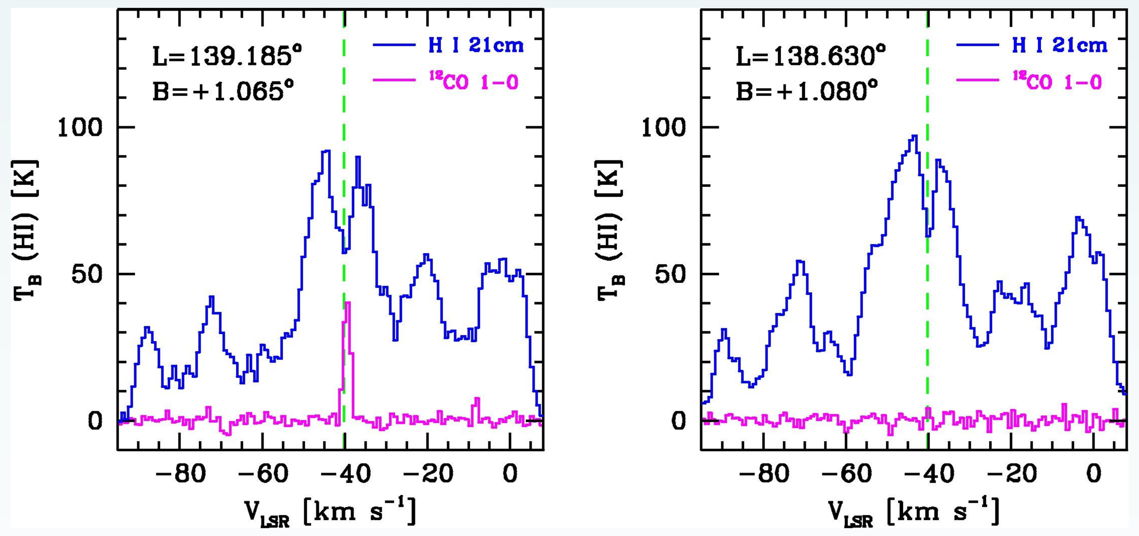
Background Information

Stars form from clouds of gas and dust that are cold and dense enough to collapse gravitationally. Most of the interstellar medium is too tenuous for this to occur, but the process is aided by the formation of H_2 and other molecules that shield the cloud interior from external radiation, allowing it to cool and contract. In our Galaxy, this process goes on all the time, even though it is hard to observe. We seek to understand the physical conditions in clouds where molecules may be forming now.



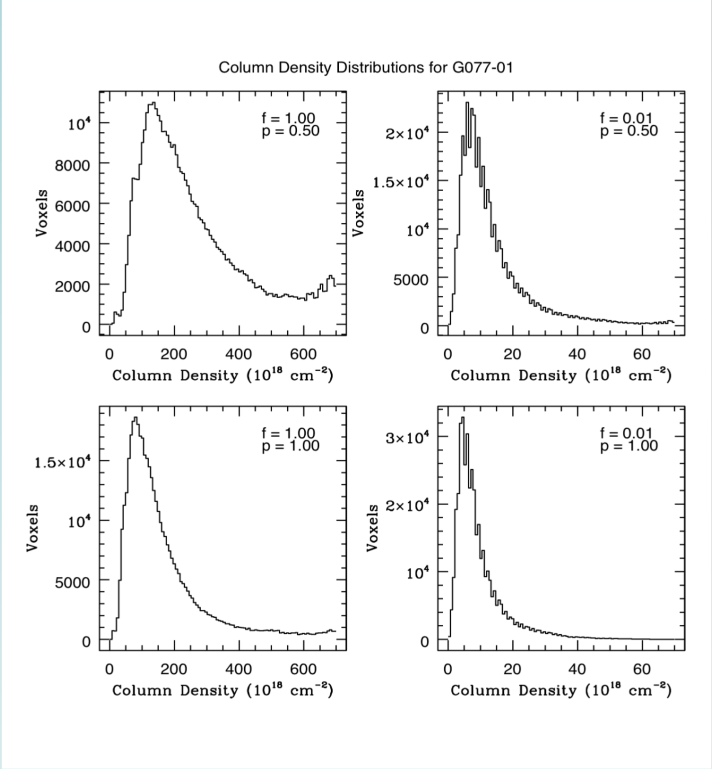
Map of neutral atomic hydrogen (HI) 21cm spectral line emission from the Canadian Galactic Plane Survey (Taylor et al. 2003), showing cold atomic gas as dark blue HI self-absorption shadows (HISA; Gibson et al. 2000) at one particular velocity within a spectral-line image cube. Magenta contours show carbon monoxide (CO).

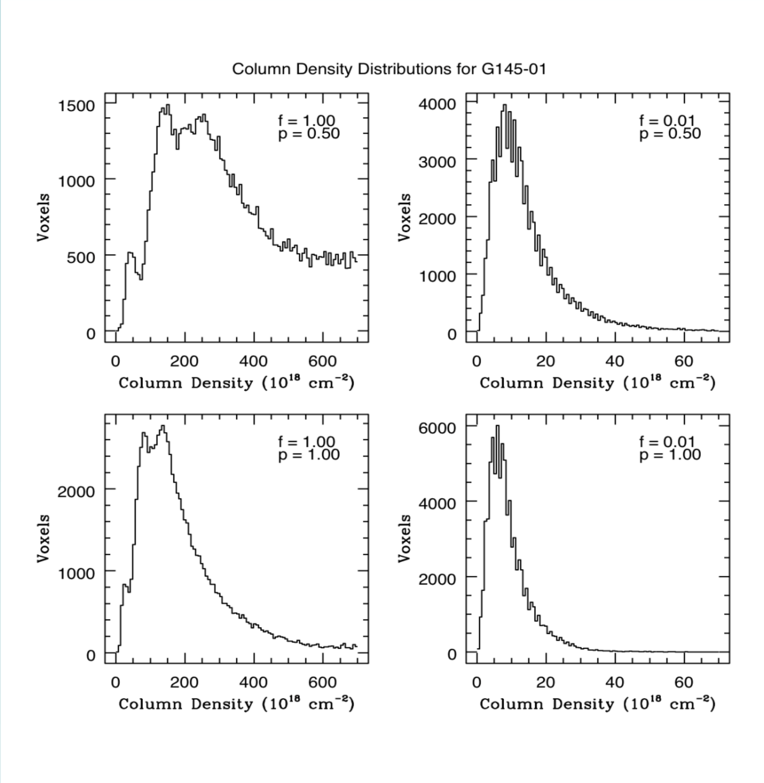


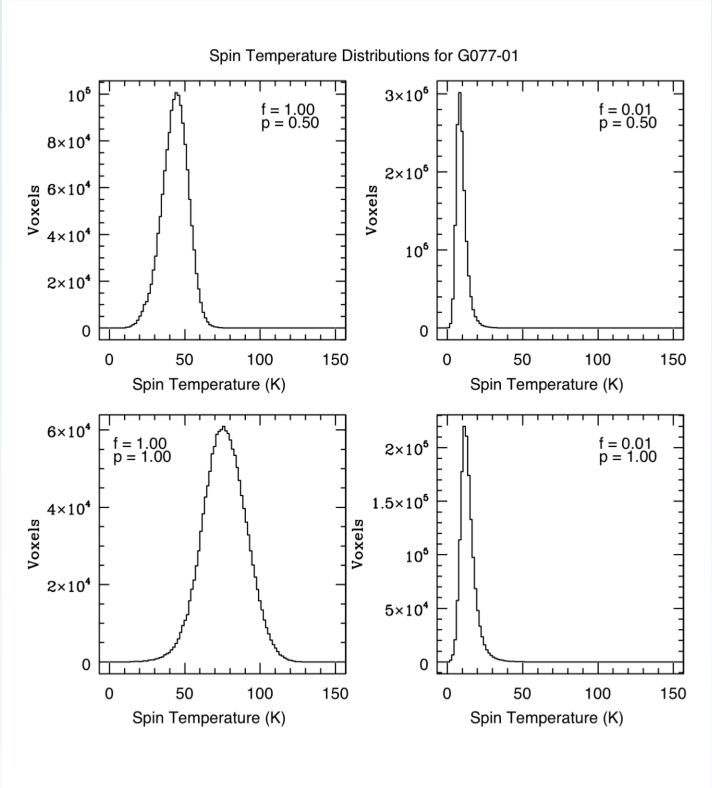
HI and CO spectra taken from positions marked with two white asterisks in the map above. The cloud on the left has a CO spike corresponding with a HISA dip, indicating cold atoms and molecules are both present. The cloud on the right has HISA without CO, so it may be in a less-developed state. There are many such clouds throughout the Galaxy (Gibson 2010).

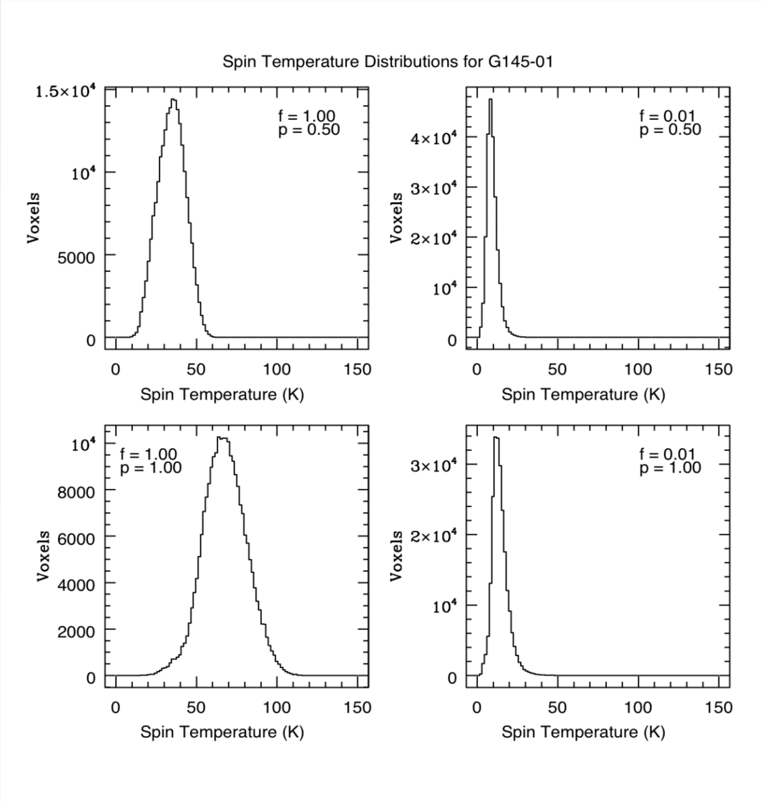
Analysis

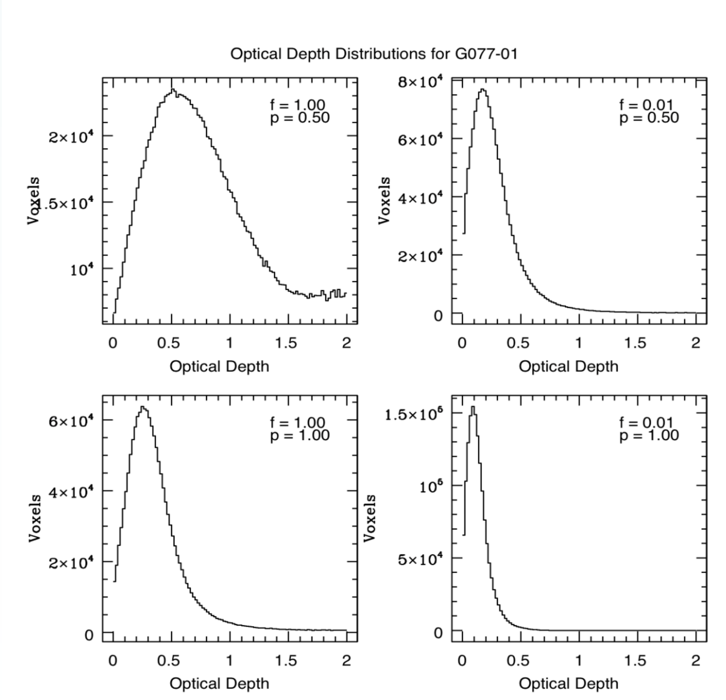
The amount of absorbed radiation in an HI self-absorption spectral line depends upon the temperature of the absorbing gas, its opacity, and other factors relevant to the radiative transfer. By combining these with line-integral properties and an ideal gas law relating density to temperature and pressure, we can constrain the gas properties in a HISA cloud for different physical scenarios (Gibson et al. 2000). We have applied this technique to different regions of the Galaxy to see how molecule-forming clouds may be influenced by their local environment. Below we give histograms of derived temperature, optical depth, and column density in two regions for different assumed sight line geometries and atomic/molecular abundances.

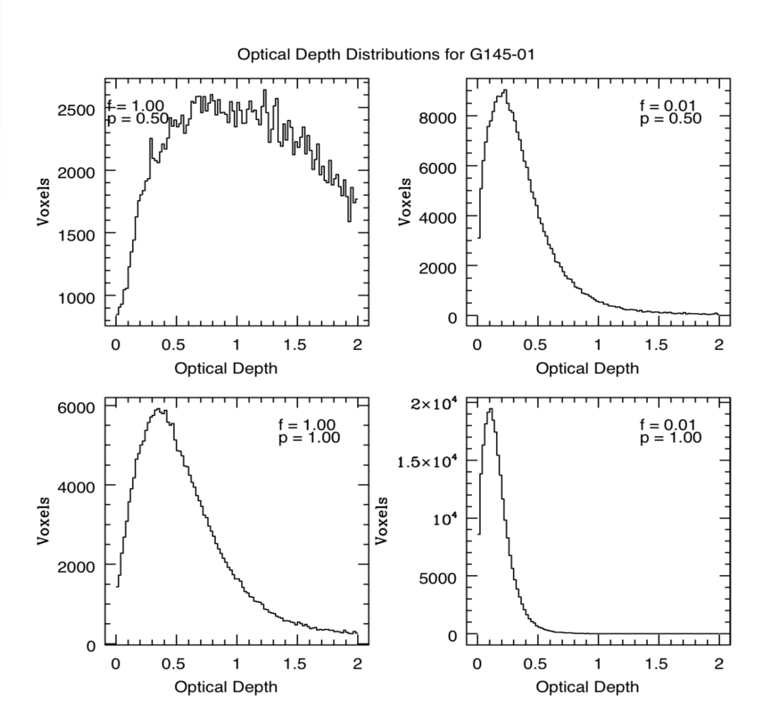






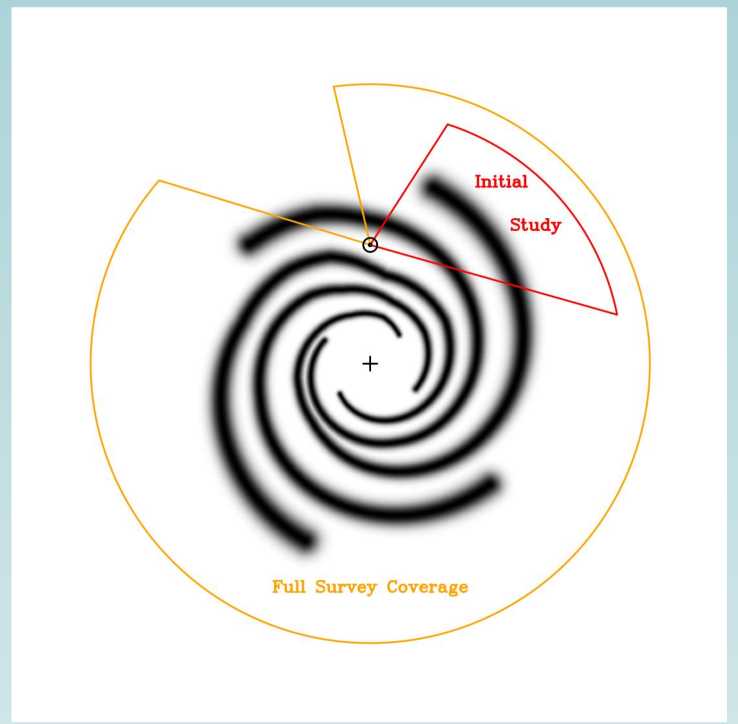






The Dominion Radio Astrophysical Observatory Synthesis Telescope, an interferometer array of 7 radio dishes in British Columbia used to observe the Canadian Galactic Plane Survey data used in our analysis.

The Andromeda Galaxy (M31), a nearby spiral galaxy similar to our own Milky Way Galaxy. [Photo credit: Tony Hallas]



A schematic representation of the spiral structure of our Galaxy, showing the area of our initial study (red), which uses HISA data extracted by Gibson et al. (2005). Subsequent HISA surveys (Gibson 2010) covering a much larger area (yellow) can be investigated later.

Results and Future Work

Although preliminary, our results show that physical scenario has a major effect on likely gas properties: pure atomic clouds tend to be much warmer than mostly-molecular ones, and since the atomic gas remaining in the latter absorbs more efficiently, less of it is needed to produce the observed HISA. Even so, there are clear differences in the derived column densities and optical depths of the two regions despite their temperature distributions being very similar. Possible reasons for this are under investigation. Future work will include a detailed comparison of properties throughout this Galactic longitude range and the larger region outlined in the schematic figure.

References and Additional Thanks

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Funding and other support for this work was provided by WKU, the Ogden College of Science and Engineering, the Gatton Academy, and the National Science Foundation.