Properties of Cold Galactic Interstellar Clouds

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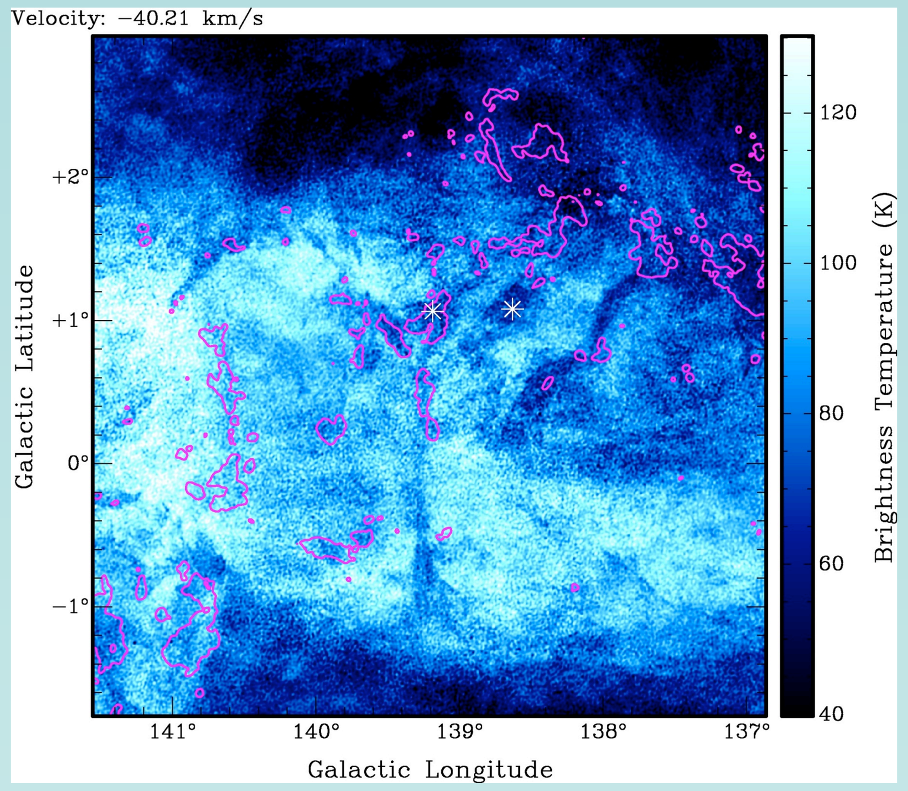
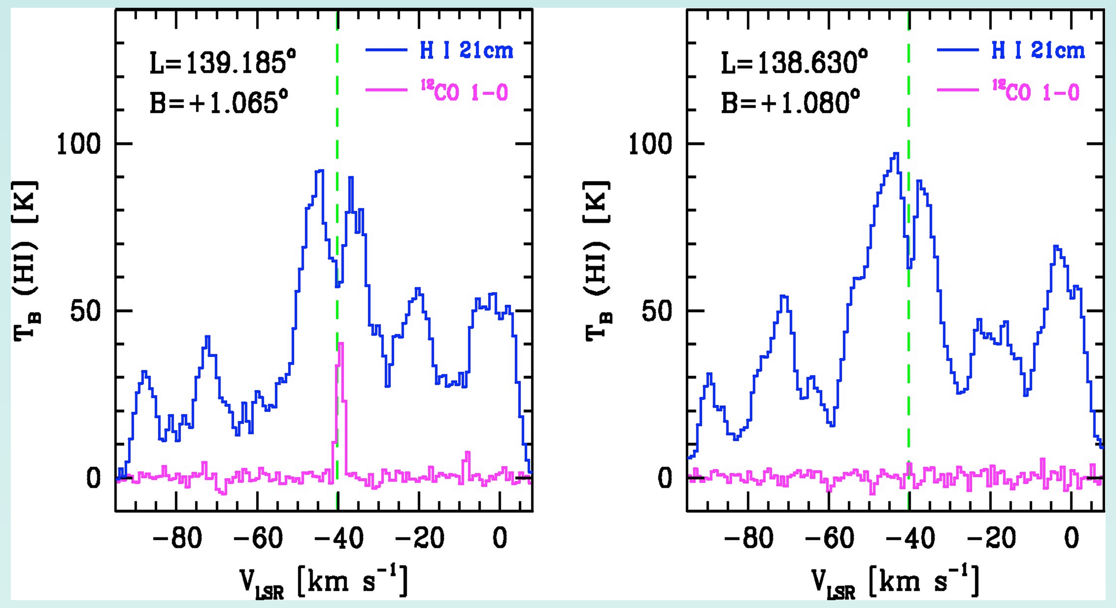
Background Information

The interstellar medium (ISM) is the gas and dust that lies in between stars and makes up a portion of mass and structure in our galaxy, the Milky Way. The structure of the ISM and its various physical processes are critical to the formation of stars. The ISM is typically too tenuous for clouds to collapse on their own, but this can still occur when molecular hydrogen (H_2) is present, because it shields the interior of the cloud from stellar radiation, which in turn allows the cloud to cool and contract. In the Milky Way, this subtle process occurs constantly, and it is important to understand the physical properties of the clouds where molecules may be forming now.



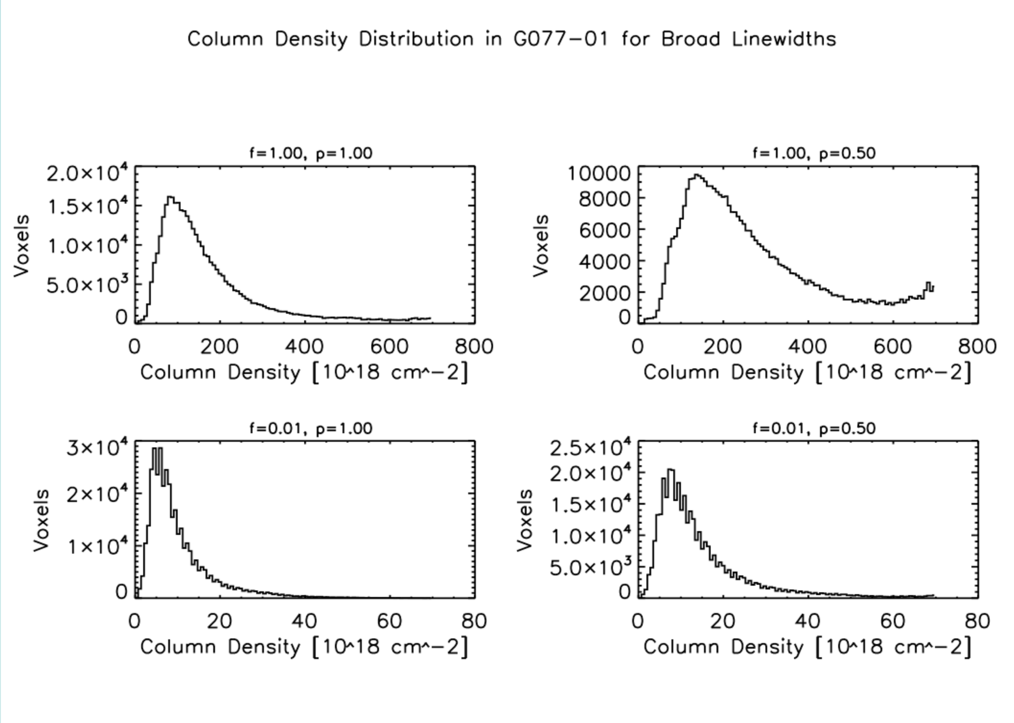
Map of neutral atomic hydrogen (HI) 21cm spectral line emission from the Canadian Galactic Plane Survey (Taylor et al. 2003), showing cold atomic gas as dark blue HI self-absorption shadows (HISA; Gibson et al. 2000) at one particular velocity within a spectral-line image cube. Magenta outlines show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

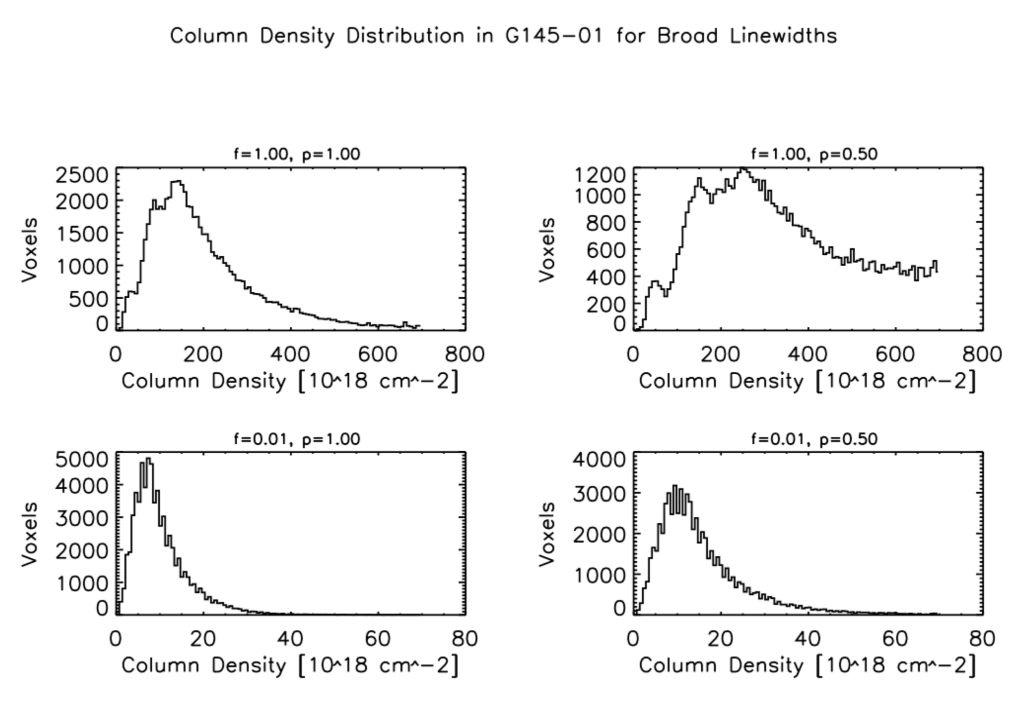


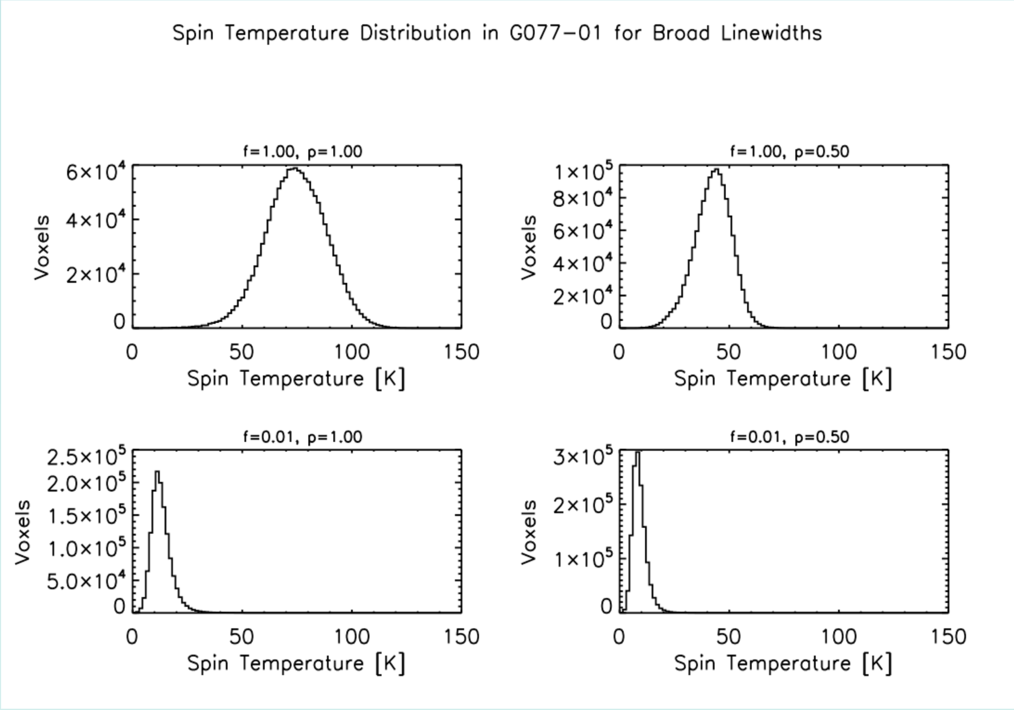
HI and CO spectra taken from positions marked with two white asterisks in the map above. The cloud on the left has a CO spike corresponding with a HISA dip, indicating cold atoms and molecules are both present. The cloud on the right has HISA without CO, so it may be in a less-developed state. There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

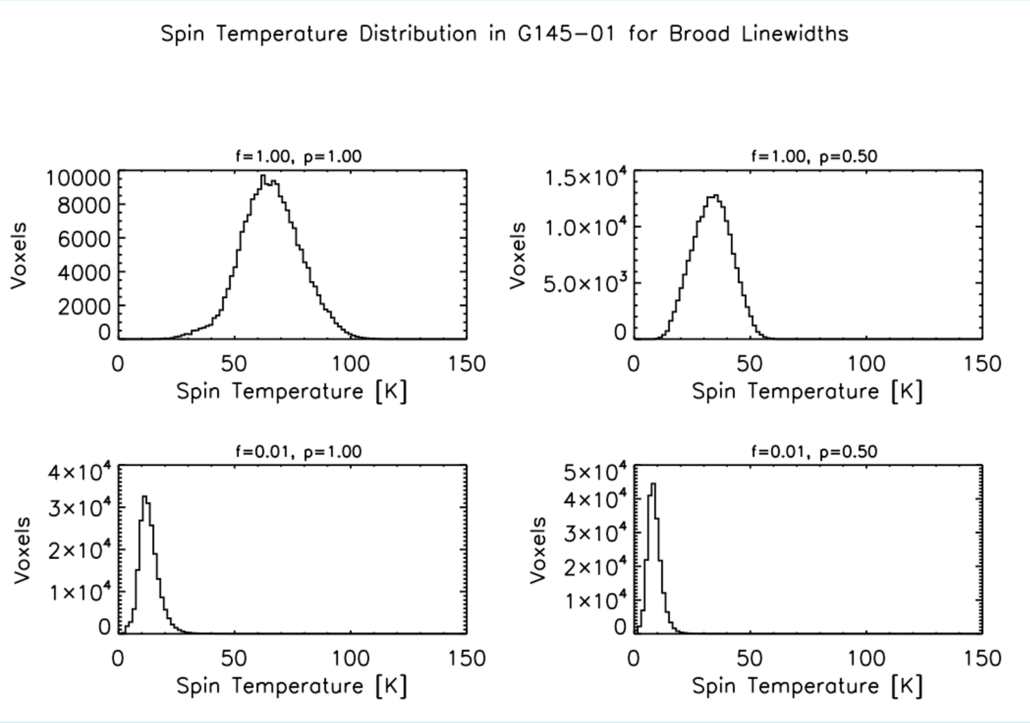
Analysis

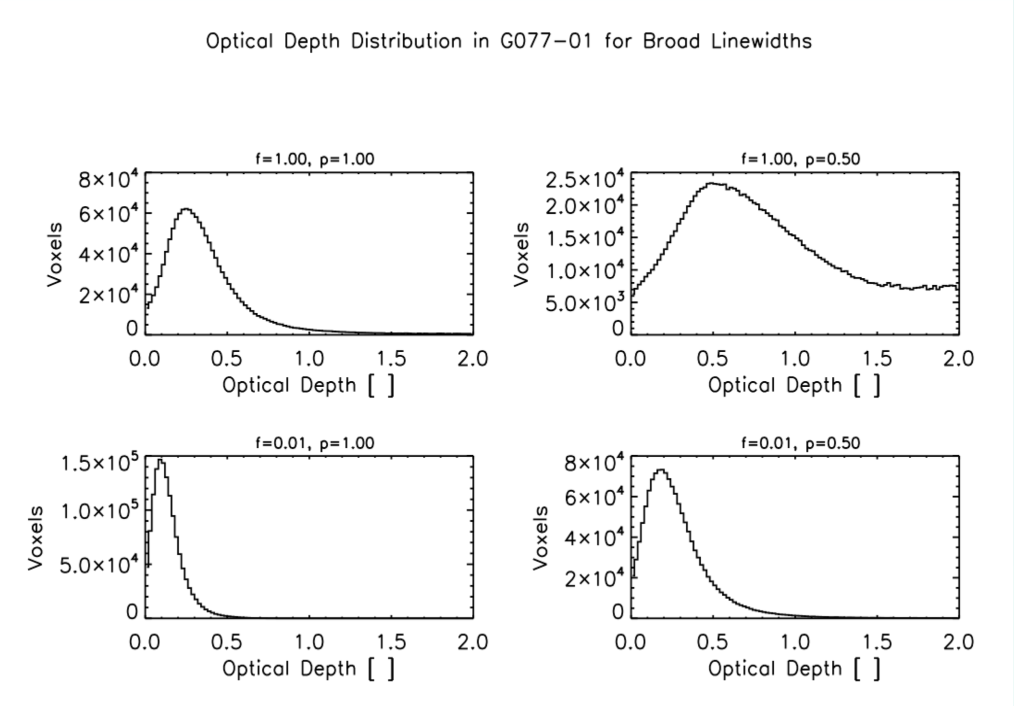
The amount of absorbed radiation in an atomic hydrogen (HI) self-absorption (HISA) spectral line depends upon the temperature of the absorbing gas, its opacity, and other factors relevant to the radiative transfer. By combining these with line-integral properties and an ideal gas law relating density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

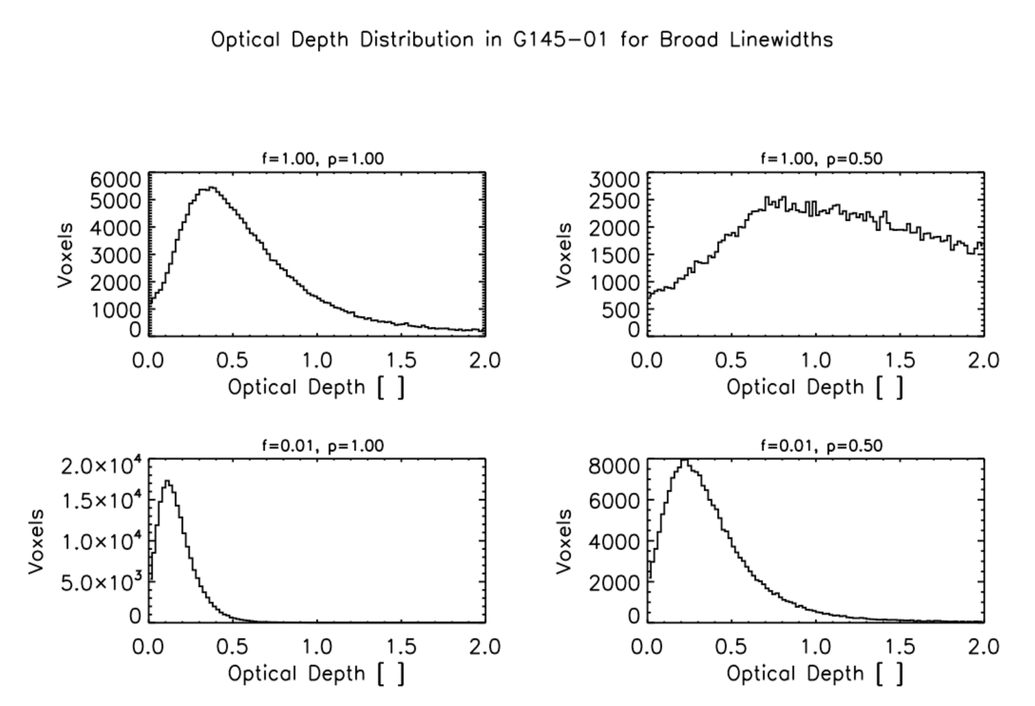






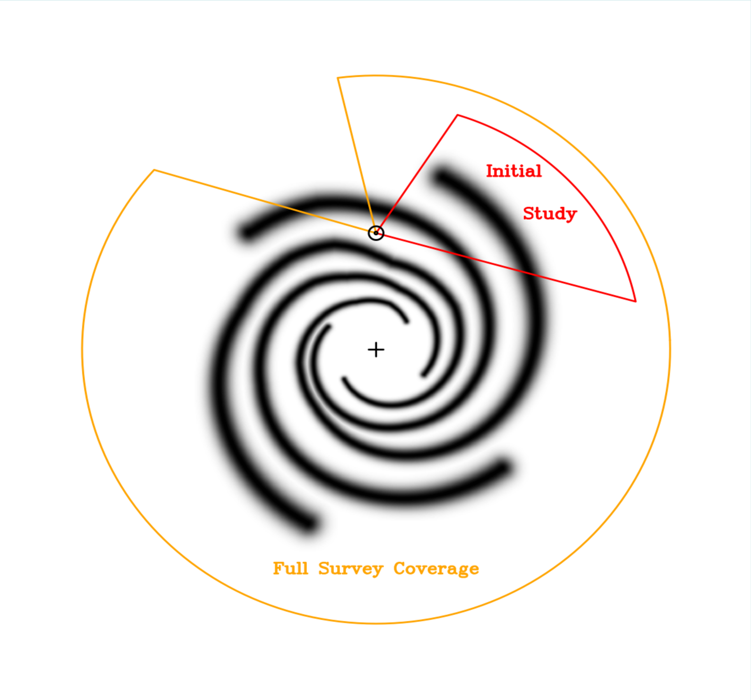






The Dominion Radio Astrophysical Observatory Synthesis Telescope, an interferometer array made up of seven connected radio dishes in British Columbia, which was used to observe the Canadian Galactic Plane Survey data used in the analysis.

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



A rough map of the Galaxy to give an idea how large of an area the survey covers: the red outline shows the area being studied in the present work, while the yellow lines indicate the larger region targeted for followup studies.

Results and Future Work

The results presented show that physical conditions have a major effect on 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. However, 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. More effort will be put into detailed and focused analysis of the full area of the Galaxy for which data are available.

References

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