Properties and Distribution of Molecular Clouds toward Camelopardalis Direction

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Introduction

Molecular clouds are key to understanding star formation, interstellar medium recycling, and the structure of the Milky Way. Stars are thought to form in the densest, coldest parts of these clouds, with their formation and evolution significantly affecting the surrounding clouds. Thus, studying the properties and distribution of molecular clouds is vital for construct a solid understanding of the above processes.

This research targets the Camelopardalis molecular cloud, situated in the second galactic quadrant (galactic longitude: 147–159 degrees; latitude: 0–8 degrees). Previous studies of this region have been limited by data resolution and sensitivity. Digel et al. (1996) identified three layers within the cloud: the Gould Belt, Cam OB1, and Perseus Arm. Straizys & Laugalys (2007) compiled data on stars, clouds, and ionized hydrogen regions in this direction, but the CfA-Columbia CO survey's resolution was inadequate for detailed analysis.

The MWISP's high-quality CO data has enabled more in-depth research. Xiong et al. (2017) used this data to study filamentary structures in the Camelopardalis, assessing star formation activity.

This study aims to leverage these data for a more comprehensive understanding of the Camelopardalis molecular cloud's distribution and properties, offering new insights into interstellar activities in the region.

Observation and Data Reduction

Observation：

This study utilizes three high-sensitivity CO isotope emission lines provided by the Galactic Plane Survey to investigate molecular clouds.

- Telescope: DLH13.7m
- Beam Width: 52 arcsec
- Molecular Line: ^{12}CO, ^{13}CO and C^{18}O的(J=1-0) emission lines
- Pixel Size: 30 arcsec × 30 arcsec
- RMS Level：
  - ^{12}CO：0.5K@0.16km/s
  - ^{13}CO：0.3K@0.17km/s
  - C^{18}O：0.3K@0.17km/s

Data Reduction：

1. GaussPy+ to decompose ^{13}CO spectra (Riener et al., 2019)
2. Acorns to identify molecular clouds (Henshaw et al., 2019)
3. FacetClumps to identify molecular clumps (Jiang et al., 2023)
4. Distance Measurement (Yan et al., 2019)
5. Properties of moelcular clouds and clumps

Identification of Moelcular clouds and clumps

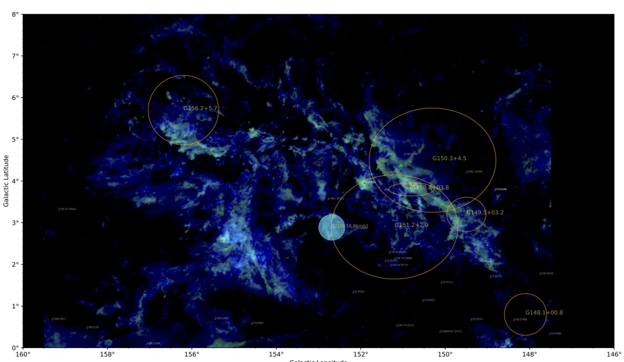

Figure 1. Overview of the Camelopardalis region, where the orange ellipse represents supernova remnants and their candidates, the cyan circle denotes ionized hydrogen regions, and the purple '+' indicate massive stars with their spectral types and distances provided.

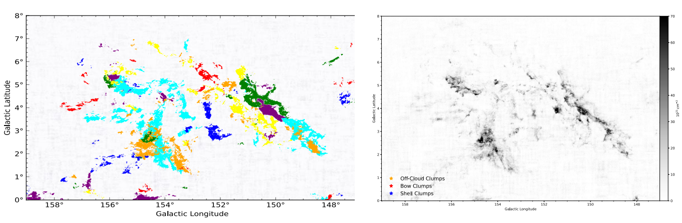

Figure 2. The left panel displays the clustering results, with different colors in various regions representing molecular clouds of different hierarchical structures. The right panel shows the results of the clump search against a background of 13CO column density distribution, with different colors indicating clumps located on different structures.

For the 13CO spectral line:

Using the Gausspy+ method to obtain in a total of 228,340 velocity components. With a voxel threshold set to 25, via Acorns method yielded 99 molecular clouds with hierarchical structures.

Using the FacetClumps method, with a minimum voxel threshold set to be 16, resulting in a total of 3,128 clumps.

Distance and Properties

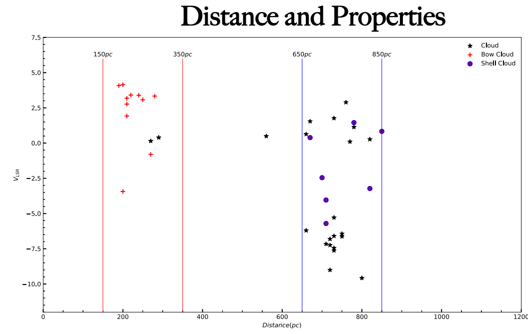

Figure 3. The distance distribution of Molecular clouds

The distances of the identified molecular clouds. Among them, 40 molecular clouds could have their distances measured with relatively high accuracy. They can be divided into two distinct groups based on distance, each with a special feature. Molecular clouds within a range of 150–300 parsecs contain Bow-shaped molecular clouds (Bow), while those within a range of 650–800 parsecs contain shell-like molecular clouds (Shell).

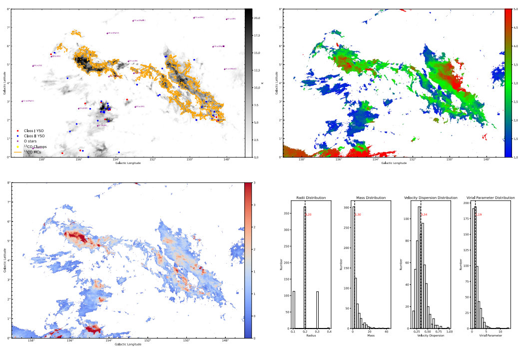

Figure 4. Distribution of Bow-shaped molecular clouds, from top left to bottom right are the integrated intensity map, velocity distribution map, linewidth map, and statistics of clump properties located within the Bow-shaped molecular clouds.

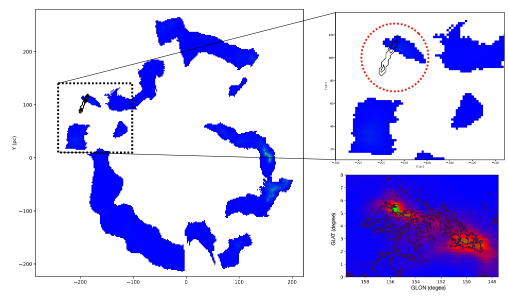

Figure 5. Arc-shaped molecular cloud in relation to the Local Bubble (O'Neill et al., 2024).

By combining dust extinction maps with the Local Bubble model, it is highly likely that the Bow-shaped molecular cloud is located on the Surface of the Local Bubble.

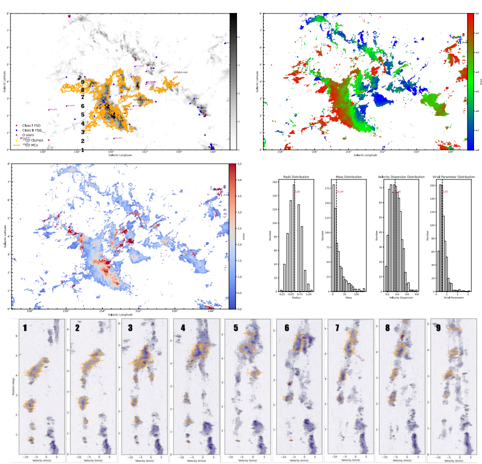

Figure 6. Distribution of shell-like molecular clouds, from top left to bottom right are the integrated intensity map, velocity distribution map, line width map, and statistics of clump properties located within the shell-like molecular clouds. The path in the integrated intensity map corresponds to the position-velocity diagram shown below.

Based on the position-velocity diagram, the expansion velocity of this shell is determined to be approximately 7.5 km/s. The radius of the shell is calculated to be about 55 parsecs, with a mass of 16,181 solar masses. The timescale of the shell is estimated to be around 7.2 million years, and the shell's kinetic energy is approximately 9.1×10^{48} ergs.

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