

ABSTRACT FOR GENERAL PUBLIC

The formation of stars occurs in clouds of dust and molecular gas which constitute the coldest and densest part of the interstellar medium in galaxies. Gravitational collapse of molecular clouds leads to their fragmentation, and the formation of smaller substructures called clumps and cores, which are the birthplaces of stars and stellar clusters. Across the whole Milky Way, a few stars, typically smaller than our Sun, are born in these structures each year. In general, over a huge range of spatial scales, from dense clumps in the Milky Way up to whole galaxies of various types, the rate of star formation is closely linked to the available reservoir of dense gas. Additional key factors are the physical and chemical properties of the environment in which the stars form.

In astronomy, metallicity offers a measure of the percentage of elements heavier than hydrogen and helium present in the gas. In our Galaxy, the metallicity is found to be decreasing with the distance from the Galactic center. As a result, the metallicity of the outer Galaxy is much lower than in the inner Galactic disk, and is similar to the Magellanic Clouds, the satellite galaxies of the Milky Way. Molecular clouds in the outer Galaxy are similar to those seen in other galaxies, but their star formation can be studied in much more detail because of the closer distance, resulting in better detection sensitivity and higher spatial resolution. *Thus, the outer Galaxy provides a unique opportunity to study the impact of reduced metallicity on star formation.* The lower metallicity causes lower abundances of dust and molecules heavier than molecular hydrogen, thereby affecting the overall gas and dust cooling budget, which is an important parameter in star formation. The average flux of cosmic rays and the ultraviolet radiation field are reduced, but both, high energy particles and radiation, penetrate deeper into the clouds, where they can heat and ionize gas.

This project aims to identify and characterize the combined effect of metallicity, physical conditions (temperature, density, ultraviolet radiation), and environment on star formation on spatial scales from cores/clumps to molecular clouds. By investigating spatial scales from cores/clumps to molecular clouds, we intend to connect the small scale physical and chemical processes and conditions to the large scale picture of star formation. *This is important, since the extreme metallicity of the outer Galaxy is similar to that of normal galaxies in the Universe at earlier stages of evolution, when star formation was at its peak. Hence, the outer Galaxy is an ideal template for studying star formation in low-metallicity systems at earlier cosmological epochs.*

Here, we will use observations collected by two submillimeter telescopes located in the Atacama desert in Chile: the 12 m Atacama Pathfinder Experiment telescope (APEX) and the 6 m CCAT Fred Young Submillimeter Telescope (FYST). By studying the emission from molecules (e.g. hydrogen cyanide) and atoms (e.g. carbon), present in molecular clouds, we will constrain the chemical composition, and physical conditions and processes taking place in the birthplaces of stars.

In the scope of the project, we expect to identify changes in molecular abundances as the metallicity decreases with the distance from the Galactic Center. The measured abundances should reflect both the chemical composition and the physical conditions of the gas, making them a powerful tool to study star formation across environments. In addition, as part of the project we aim to detect a significant amount of atomic/ionic gas. This gas results from the destruction of molecules due to UV radiation and is often called "CO-dark gas". CO is the second most abundant molecule in the Universe, commonly used to estimate the amount of molecular hydrogen, and ultimately the total mass of the gas in molecular clouds. In some galaxies, as much as 70% of the molecular gas may be "hidden", i.e., molecular, but undetectable in CO, since it is destroyed by UV photons (Madden et al. 2020). In the outer Galaxy, we expect a similar effect. Using state-of-the-art models of molecular clouds, we intend to characterize ultraviolet radiation and cosmic rays in the outer Galaxy and understand their impact on star formation, guiding the interpretation of observations in other galaxies.