The history of C, N, and O in the Galaxy

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Among all the chemical elements in the periodic table, carbon, nitrogen, and oxygen (CNO) are the three most abundant elements in the Universe, excluding hydrogen and helium. These last two elements are produced in large amounts in the primordial nucleosynthesis that takes place just a few minutes after the Big Bang. Carbon, nitrogen, and oxygen are instead chemical elements produced inside stars.

Carbon, nitrogen, and oxygen are essential for life as we know it and therefore are expected to also play a fundamental role in the basic chemistry of extraterrestrial life. They are part of all the main molecules that are currently considered biomarkers in exoplanetary atmospheres (for example, CO_2, H_2O, CH_4, and N_2O). Therefore, a better understanding of the origin and history of CNO also has implications for the quest to find life in the Universe.

In this project, we will study the abundances of CNO in a large set of stars that belong to all stellar populations of the Milky Way. We propose a novel analysis strategy to obtain results that are more precise than before, taking advantage of an improved methodology that has been developed by us in the last few years. The method uses a set of reference stars for which we can determine surface temperatures and gravities that are accurate to 1%. Thanks to that, it is possible to determine the abundances of chemical elements and stellar ages with a higher quality than the results that are currently available. We will use our new results to investigate the history of chemical enrichment of the Galaxy and stellar evolution.

Combining abundances and ages with stellar orbits, we can study the history of radial migration of stars. During their lifetimes, stars can move (or migrate) away from the regions where they were born. To understand the details of the CNO enrichment as a function of the Galactic radius in a large volume of the Milky Way, we first need to pinpoint the Galactic region from which each star comes. By doing that, we will be able to reconstruct the time scales of CNO production and identify the main types of stars that function as sources of these elements.

In addition, the abundances of CNO measured in the atmosphere of stars can be affected by several physical processes that mix the stellar surface with material from their interiors. In this project, we plan to focus particularly on investigating the effects related to magnetic activity. Precise abundances and ages will be studied together with the measurement of activity indicators. This will help to better quantify the role of magnetic activity on the transport of chemical elements inside stars.

Together, these efforts will help to clarify with unprecedented detail the intricacies of the history of C, N, and O in the Galaxy, providing important input to improve our understanding of Galactic and stellar evolution.