

Helium abundance in the catalog of HII regions in the CALIFA survey

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Abstract

We explore for the first time the helium abundance spatial distribution in a sample of galaxies representative of the local Universe as is the CALIFA survey. We use the catalog of spectral properties of HII regions for the CALIFA sample. To derive the helium abundance we select those HII regions with reliable estimation of the flux from the most intense line of HeI $\lambda 5875$. With a sample covering a wide range of galaxy properties we are in the position to quantify whether or not global properties of galaxies such as total stellar mass, morphology among others have a strong impact in the derived Helium radial gradients. Furthermore, this exploration will be the benchmark to constrain chemical evolutionary models at kpc scales.

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The study of chemical abundances in some galaxies and our galaxy indicates the presence of radial gradients of heavy elements such as O, N, Ne, S, Ar, or Cl (e.g. Carigi et al. 2005; Balser et al. 2011; Esteban & García-Rojas 2018). The form of such gradients reflects the action of stellar nucleosynthesis, the distribution, and history of star formation and gas flow in the chemical evolution of the Galaxy. Although the helium abundance should increase with the metallicity, still there is no clear evidence of the presence of a radial gradient of this element.

The helium is the second most abundant element in the Universe and constitutes about 24-25% of its baryonic mass. The vast majority of the cosmic helium was produced during the primordial nucleosynthesis phase just after the Big Bang. At these stages, helium is produced by hydrostatic nucleosynthesis in the interior of stars of all initial masses. Low-mass stars produce this element through the proton-proton chain while intermediate-mass and massive ones via the CNO cycle. The amount of this element that is actually ejected by a given star and enriches the ISM depends on its initial mass and the importance of stellar winds (Méndez-Delgado et al. 2020).

In this work, we explore for the first time the helium abundance spatial distribution in the catalog of spectral properties of HII regions obtained by Espinosa-Ponce, et al. 2020, for the CALIFA sample.

The helium abundance was determined from the $\text{HeI } \lambda 5876/\text{H}\beta$ ratio, corrected for extinction, using the electron temperature $T_e=10,000$ (the temperature in the high excitation zone) and the electron density $n_e=300$, where $\lambda 5876$ is the most intense line of HeI in the optical range. The computations carried out in PyNeb (Luridiana et al. 2013), and a Monte Carlo simulation was applied to estimate the uncertainty of the He^+/H^+ ratios derived for each region. In this work, we are going to compare the helium abundance obtained from the CALIFA sample with the helium abundance obtained from literature. And we are going to propose a calibrator to estimate the helium abundance in HII regions.

Helium abundances in the literature

We performed a search in the literature of HII regions where it has been estimated the helium abundance. We looked for those targets in previous works where the authors estimated the helium abundances using the He lines in the optical range that include $\lambda 3819$, $\lambda 4026$, $\lambda 4471$, $\lambda 4712$, $\lambda 4922$, $\lambda 5875$, and $\lambda 6677$.

Our compilation is based on 198 HII regions from 6 different works in the literature, from which 48 are galactic and 150 are extragalactic.

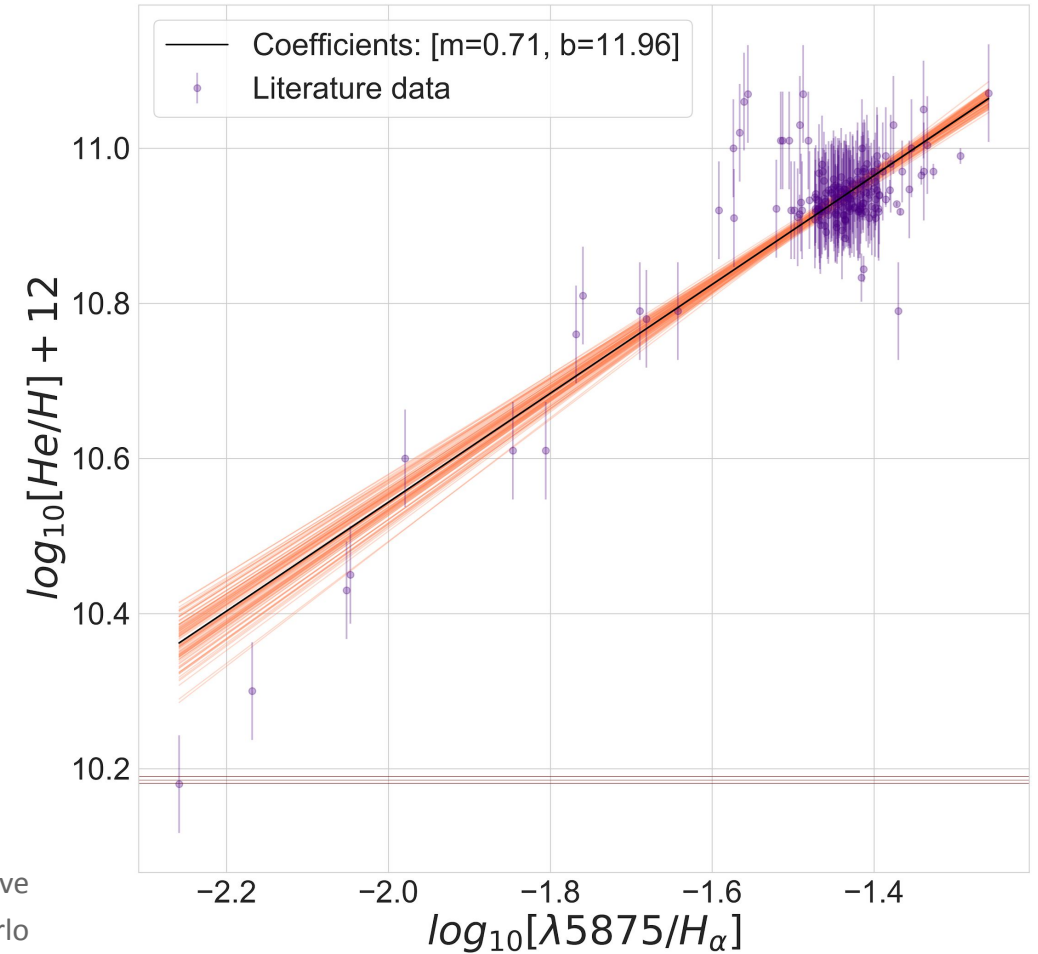


Figure 1. In this plot, we show the helium abundance versus He I line $\lambda 5875/H_{\alpha}$. We have obtained the best fit line using the least-squares method through a Monte Carlo simulation. The horizontal line represents the primordial helium abundance and this value is a lower limit.

We have analyzed the catalog of HII regions obtained by Espinosa-Ponce et al. (2020) for the CALIFA survey. To derive the helium abundance, we select those HII regions with a reliable estimation of the flux of the HeI line $\lambda 5875$. To compute the abundance, we used PyNeb.

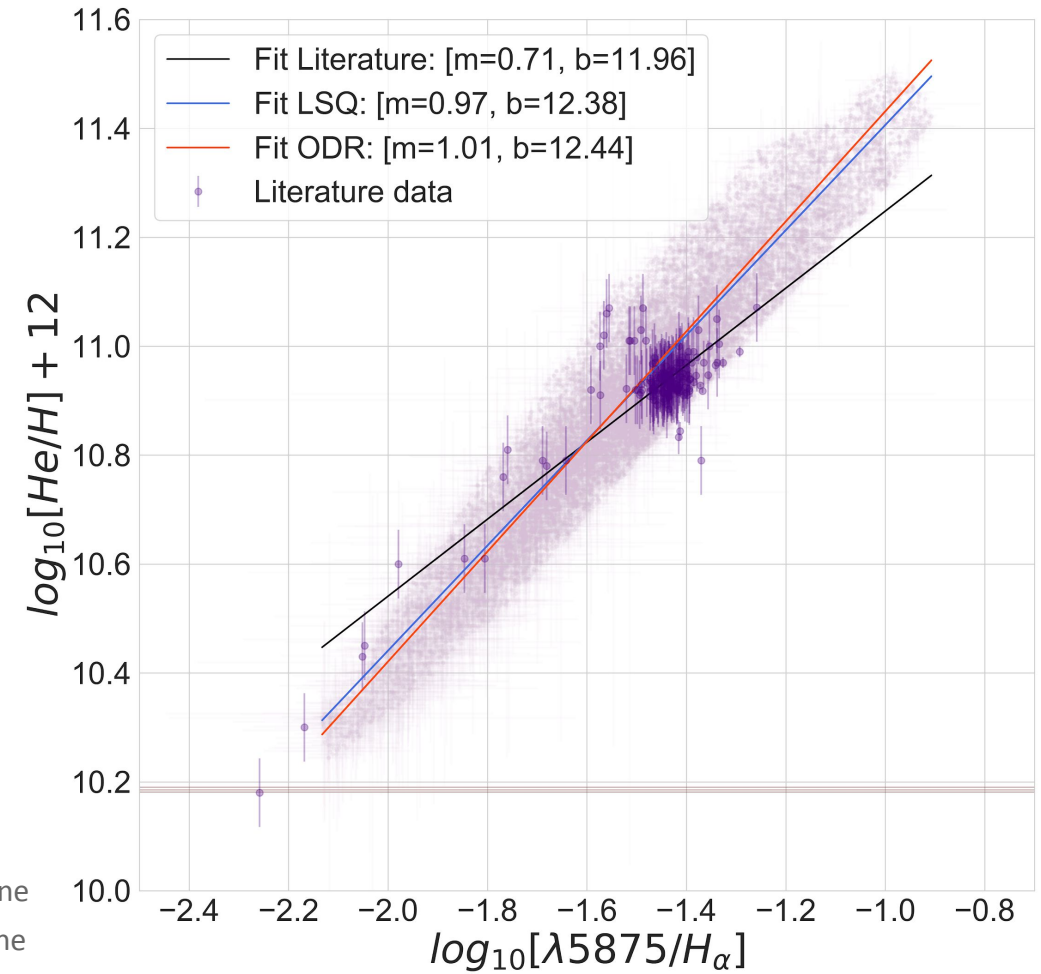


Figure 2. In this plot, we show helium abundance in the CALIFA sample versus HeI line $\lambda 5875/H_{\alpha}$. We have done ODR and LSQ fits for the CALIFA sample, and we show the comparison with the literature fit.

Summary

- We have computed helium abundance in the catalog of HII regions for the CALIFA sample.
- We have compiled a sample from the literature with helium abundance measurements in HII regions.
- We have compared the helium abundance obtained from the CALIFA sample with the helium abundance obtained from the literature.
- We are going to propose a calibrator to estimate the helium abundance in HII regions.
- With a sample covering a wide range of galaxy properties, we can study the presence of a radial gradient of helium, and we will be in the position to constrain chemical evolutionary models at kpc scales.