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The CALIFA survey: Oxygen abundances.

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Abstract. We present here the last results we obtained on the spatial resolved analysis of the ionized gas of disk-dominated galaxies based on CALIFA data. CALIFA is an ongoing IFS survey of galaxies in the Local Univese ($0.005< z <0.03$) that has already obtained spectroscopic information up to $\sim 2.5 r_e$ with a spatial resolution better than $\sim$1 kpc for a total number of an statiscal sample of galaxies of different morphological types, covering the CM-diagram up to Mr< -18 mag. With nearly 2000 spectra obtained for each galaxy, CALIFA offer one of the best IFU data to study the starformation histories and chemical enrichment of galaxies. In this article we focus on the main results based on the analysis of the oxygen abundances based on the study of ionized gas in H II regions and individual spaxels, and their relations with the global properties of galaxies. In summary we have found that: (1) the $\mathcal{M}$-Z relation does not present a secondary relation with the star-formation rate, when the abundance is measured at the effective radius; (2) the oxygen abundance present a strong correlation with the stellar surface density (Σ-Z relation); (3) the oxygen abundance profiles present three well defined regimes, (a) an overall negative radial gradient, between $0.5-2$ r_e, with a characteristic slope of $\alpha_{O/H} \sim -0.1$ dex/r_e, (b) an universal flatenning beyond $>2 r_e$ and (c) an inner drop at $<0.5 r_e$ which presence depends on the mass. All these results indicates that disk-galaxies present an overall inside-out growth, although with clear deviations from this simple scenario.

Keywords. Galaxies: abundances ; Galaxies: fundamental parameters ; Galaxies: ISM

1. CALIFA: A breif introduction

The Calar Alto Legacy Integral Field Area (CALIFA) survey (Sánchez *et al.*(2012)) is an ongoing large project of the Centro Astronómico Hispano-Alemán at the Calar Alto observatory to obtain spatially resolved spectra for 600 local ($0.005< z <0.03$) galaxies by means of integral field spectroscopy (IFS). CALIFA observations started in June 2010 with the Potsdam Multi Aperture Spectrograph (PMAS), mounted to the 3.5m telescope, utilizing the large (74"×64") hexagonal field-of-view (FoV) offered by the PPak fiber bundle (Verheijen *et al.* 2004). Each galaxy is observed using two different setups: (i) V1200, $R \sim 1650$, [3700-4700Å], and (ii) V500, $R \sim 850$ [3750-7500Å]. A diameter-selected sample of 939 galaxies were drawn from the 7th data release of the Sloan Digital Sky Survey (Walcher *et al.*(2014)). The survey was completed in terms of its observations. It has acquired data for more than 600 galaxies, that will be deliver to the public in Spring 2016. The most recent data release comprises 200 galaxies (http://califa.caha.es/DR2/).

2. Results of our studies of the ionized regions

A summary of the most recent results obtained with CALIFA has been presented in Sánchez (2015). In here we highlight just the most recent results on the study of the oxygen abundance profiles in galaxies.

In Sanchez *et al.* (2014) we proposed the existence of a characteristic abundance gradient in disk galaxies, with a slope of $\alpha_{O/H} = -0.1$ dex/r_e, based on the analysis of a

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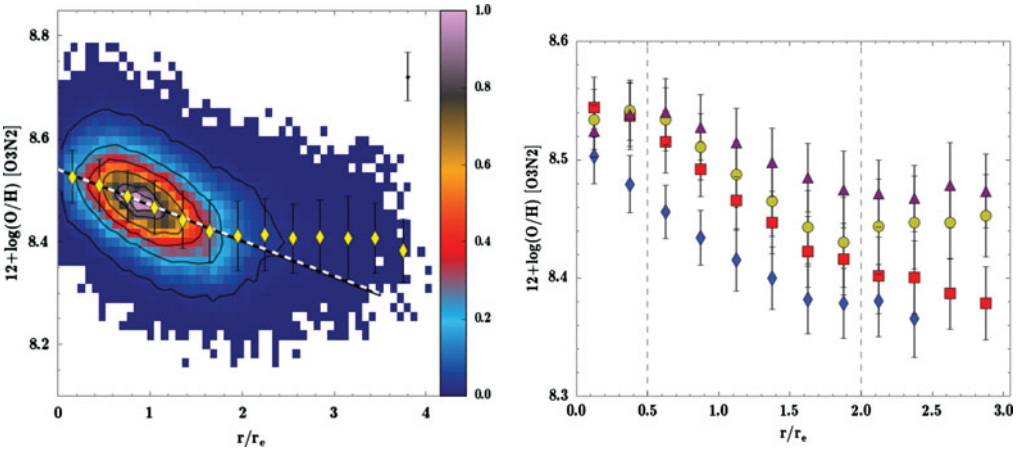

Figure 1. . *Left panel:* Radial density distribution of the oxygen abundance after re-scaling the oxygen abundances of each galaxy following the $\mathcal{M}$-Z relation. *Right Panel:* Mean oxygen abundance radial profiles derived considering galaxies in four different bins according to their integrated stellar mass. The limits of the bins were chosen to ensure a similar number of elements in each bin: log (M/M) < 10.1, blue diamonds; 10.1 < log (M/M) < 10.35, red squares; 10.35<log (M/M)<10.65, yellow dots; log (M/M)>10.65, purple triangles. Dashed vertical lines delimit the three different behaviours in the oxygen abundance profiles.

catalog of ∼7000 H II regions extracted from 306 CALIFA datacubes. No significant differences are found on the basis of the morphological type, presence or absence of bars, absolute magnitude and/or stellar mass. The only clear deviation from the common slope is seen in galaxies with evidence of interaction or undergoing a merging process.

These results has been recently confirmed by a study performed both using ∼7000 H II regions and ∼180.000 individual spaxels for 122 face-on spiral galaxies from the CALIFA survey (Sánchez-Menguiano *et al.*, submitted). It was found that the abundance profiles present three well defined ranges with different behaivors: (1) within ∼0.5-2r_e, the abundance profile present a negative gradient with a common slope ranging between −0.07 dex/r_e and −0.14 dex/r_e, depending on the adopted calibrator; (2) beyond >2r_e all galaxies seem to present a flatenning in the abundance gradient irrespectively of their properties (morphological type, mass, luminosity); and (3) within <0.5r_e some galaxies present drop/flatenning in the abundance distribution, deviating from the overall negative gradient, that seems to depend on the stellar mass of the galaxy (being more intense at higher masses). Figure 1 illustrates these results, showing the common abundance gradient (left-panel), and the different shapes in the abundance profile at different masses (righ-panel), where the three ranges/behaivors described before are evident. For these particular case it was adopted the O3N2 calibrator proposed by Marino *et al.*(2013).

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