On the dependence of the gradients of O/H and N/O on stellar age in MaNGA galaxies

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ESTALLIDOS

AIM: explore the **connection between metal content & chemical history with the evolution of the stellar content** in galaxies with regions of star formation.

We have **derived the abundance distribution and corresponding radial gradients** of the **oxygen** abundance and the **N/O** abundance ratio for a large sample of **1431** nearby **galaxies** from MaNGA (DR15)

We have studied these **gas-phase O/H and N/O and their radial gradients Versus age of the stellar** content of MaNGA galaxies (as traced by D4000) and along the range of **galaxy stellar mass** covered by the sample.

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Astronomy & Astrophysics

The dependence of the gradients of oxygen and nitrogen-to-oxygen on stellar age in MaNGA galaxies

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The abundance gradients derived: examples

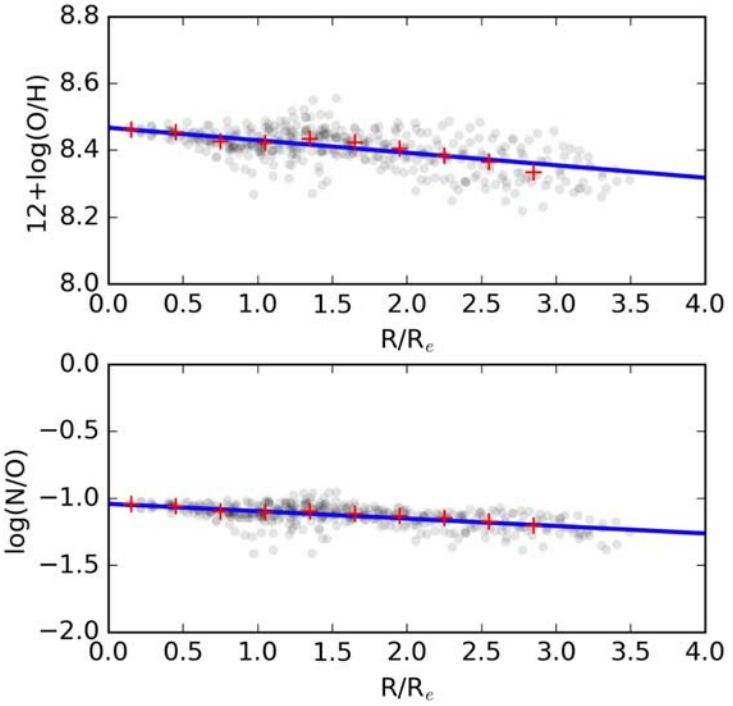


Fig. 1. Example of the radial gradients of O/H (*upper panel*) and N/O (*lower panel*) in the MaNGA galaxy 1-48157 using data from data cube 10001-12701. Grey points are values in each spaxel, derived from the empirical R calibration of Pilyugin & Grebel (2016). Red crosses are median values in bins. A solid line is the linear fit to the data.

R calibration

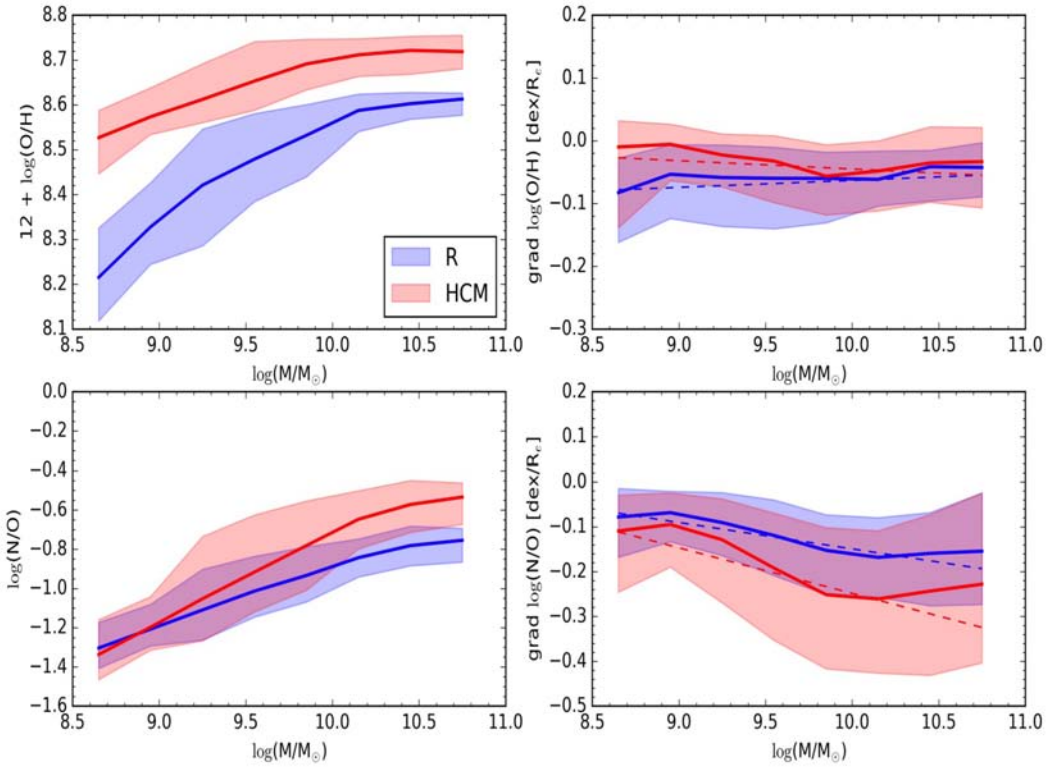


Fig. 4. Galaxy-centre oxygen abundance log(O/H), nitrogen-to-oxygen ratio log(N/O), and their gradients as a function of galaxy mass $\log(M/M_\odot)$. Median values (solid lines) with 1-σ range scatter (shaded areas) are shown in each mass bin. The metallicity parameters were calculated using the following two methods: the R calibration (blue lines and areas) or the HCM method (red lines and areas). For the O/H and N/O gradients, dashed lines show linear fits as a function of the stellar mass.

Abundances measured at the center !

Mass-Metallicity

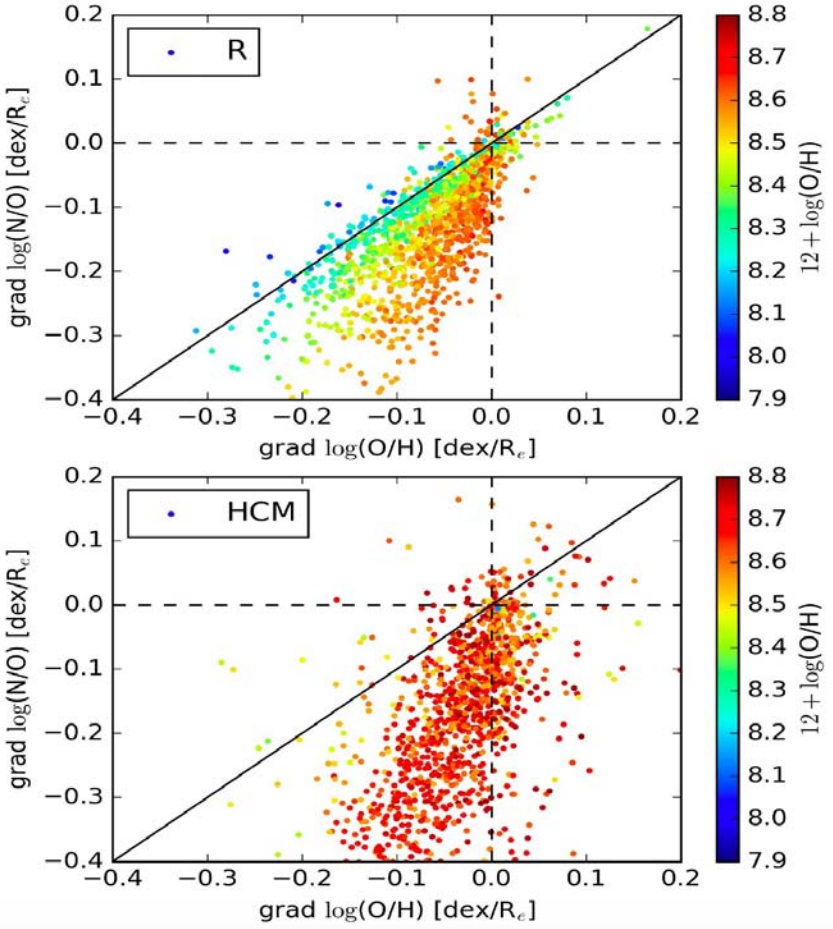
N/O – Mass

Gradients vs. Mass

USED
Models
HII-Chi-Mistry
(EPM)

Calibration
R
(Pilyugin+)

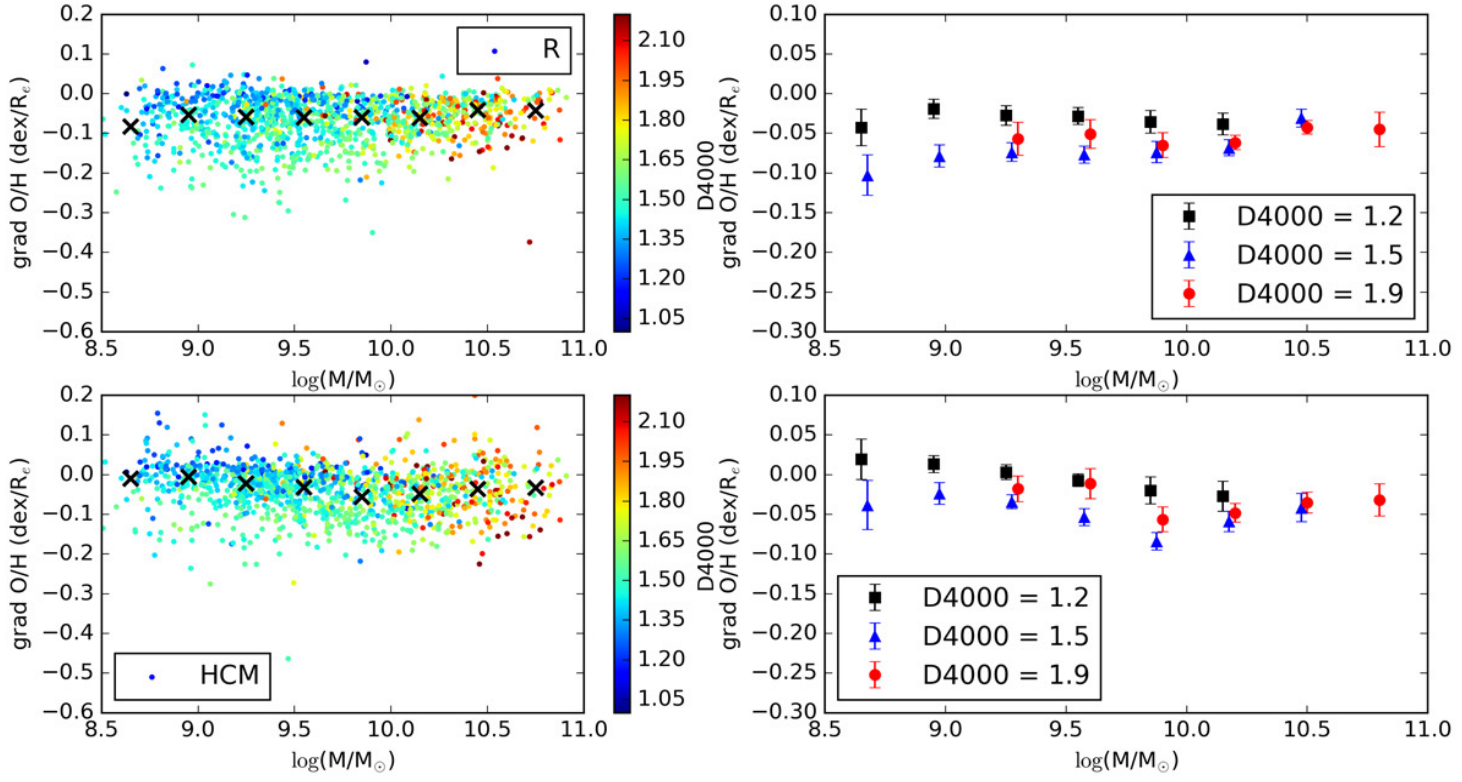
Log O/H vs. Log N/O Gradients



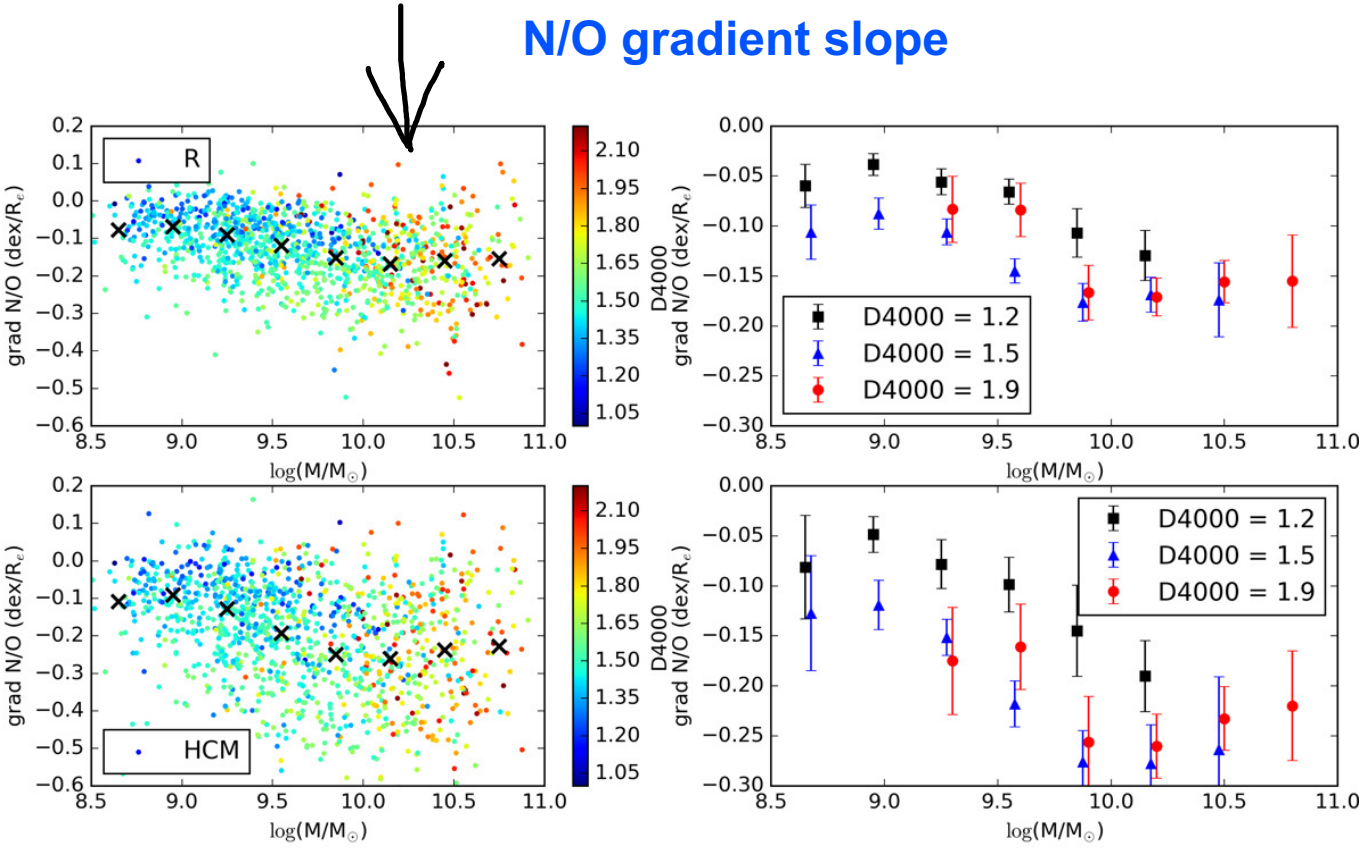
Comparison of oxygen abundance log(O/H) gradient and log(N/O) ratio gradient for metallicities obtained from the R calibration (top panel) or the HCm method (bottom panel).

Colour denotes the oxygen abundance at Re. Black dashed lines are zero gradients. Solid black line is a one-to-one correspondence for reference.

O/H gradient slope



N/O gradient slope



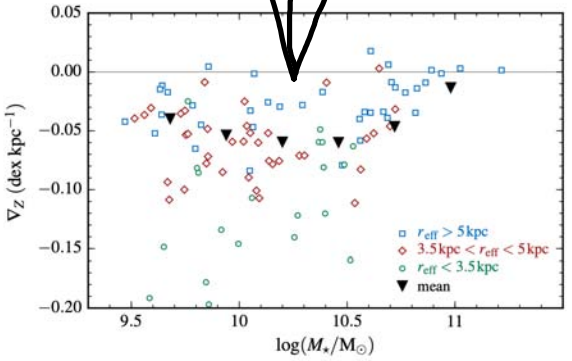


Fig. 4. Metallicity gradients as a function of stellar mass for all analysed redshifts. The colours denote different sizes of the discs $r_{eff} > 5$ kpc (blue stars), 3.5 kpc $< r_{eff} < 5$ kpc (red stars) and $r_{eff} < 3.5$ kpc (black stars). Mean gradients for the stacked distribution are shown (black triangles).

Tissera+ 2017.

Galaxies' Simulations

Evolution of the *metallicity gradients of the whole stellar populations* in disc components of simulated galaxies in a cosmological context.

=> *Mild evolution* with redshit.

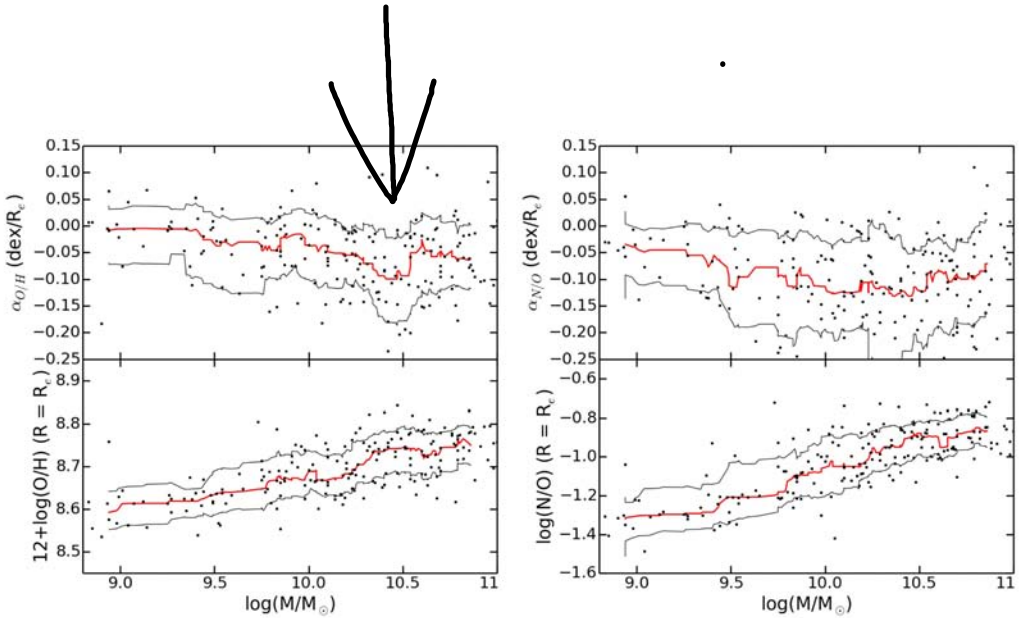


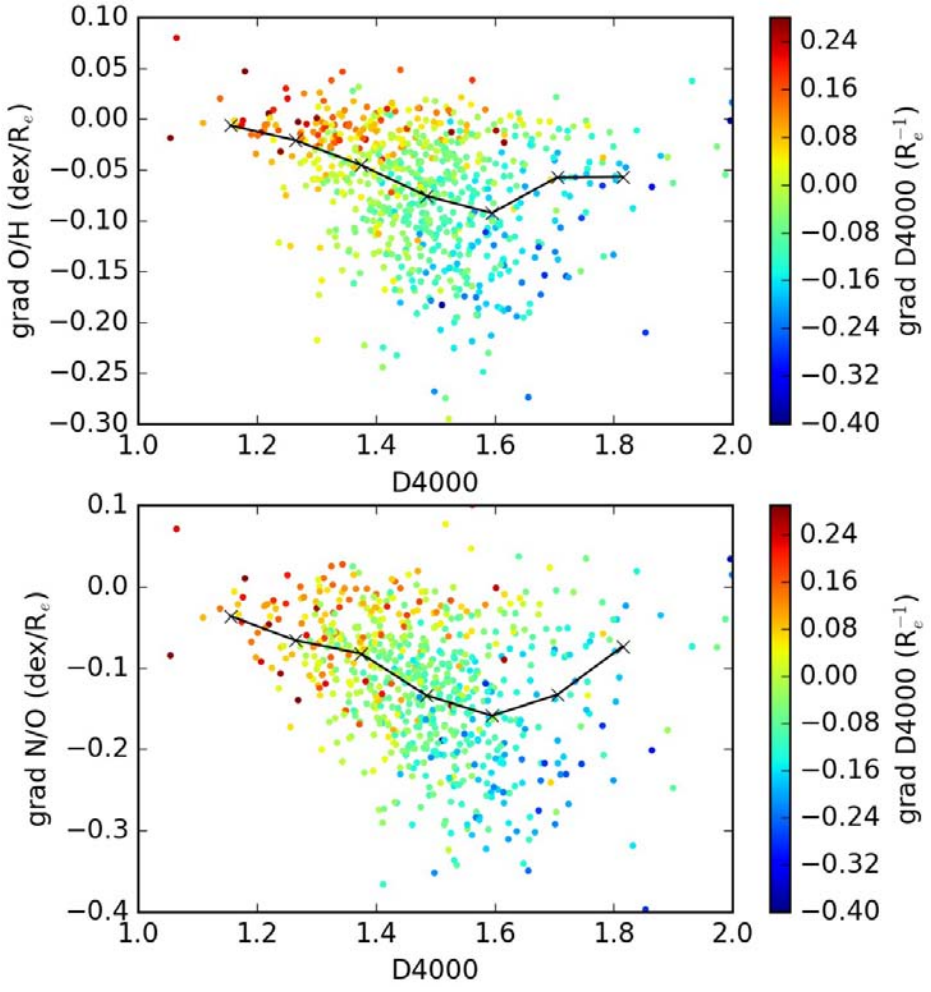
Fig. 13. Relation between the total stellar mass and the derived slopes and characteristic values at the effective radius for O/H (*left panels*) and N/O (*right panels*). The red and black solid lines have the same meaning as in Fig. 12.

Pérez-Montero, Garcia-Benito, Vilchez+ 2015.

Abundance gradient slope of CALIFA Galaxies

Some models: Molla+ 2019 for MW type; Belfiore+ 2019

Following Sharda+ 2021; Belfiore+2017, Zinchenko+ 2019
Some flattening of the present day metallicity gradient with stellar mass is expected (-> towards high Masses).



O/H gradient (*top panel*)

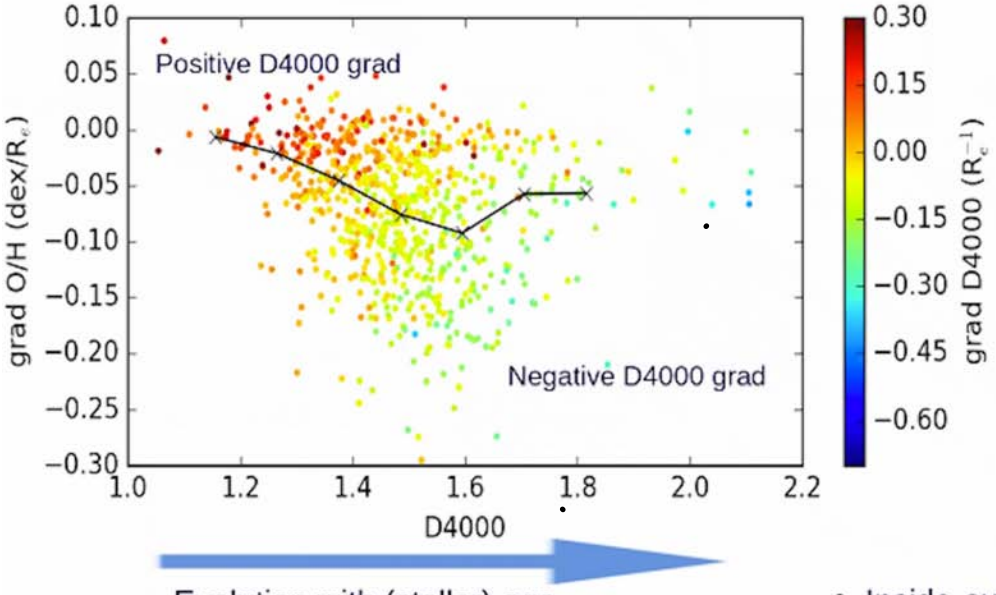
N/O gradient (*bottom panel*)

as a function of the *D*(4000) index

Colour-coded gradient of *D*(4000) for abundances derived from the **R** calibration (see the text for details).

Crosses connected by solid lines present median abundance gradient values in each bin of *D*(4000)

Mass – O/H gradient – D4000



Evolution with (stellar) age

- Inside-out growth of a disk
- SFH is important

Positive D4000 grad. = younger stars in the center

Negative D4000 grad. = older stars in the center

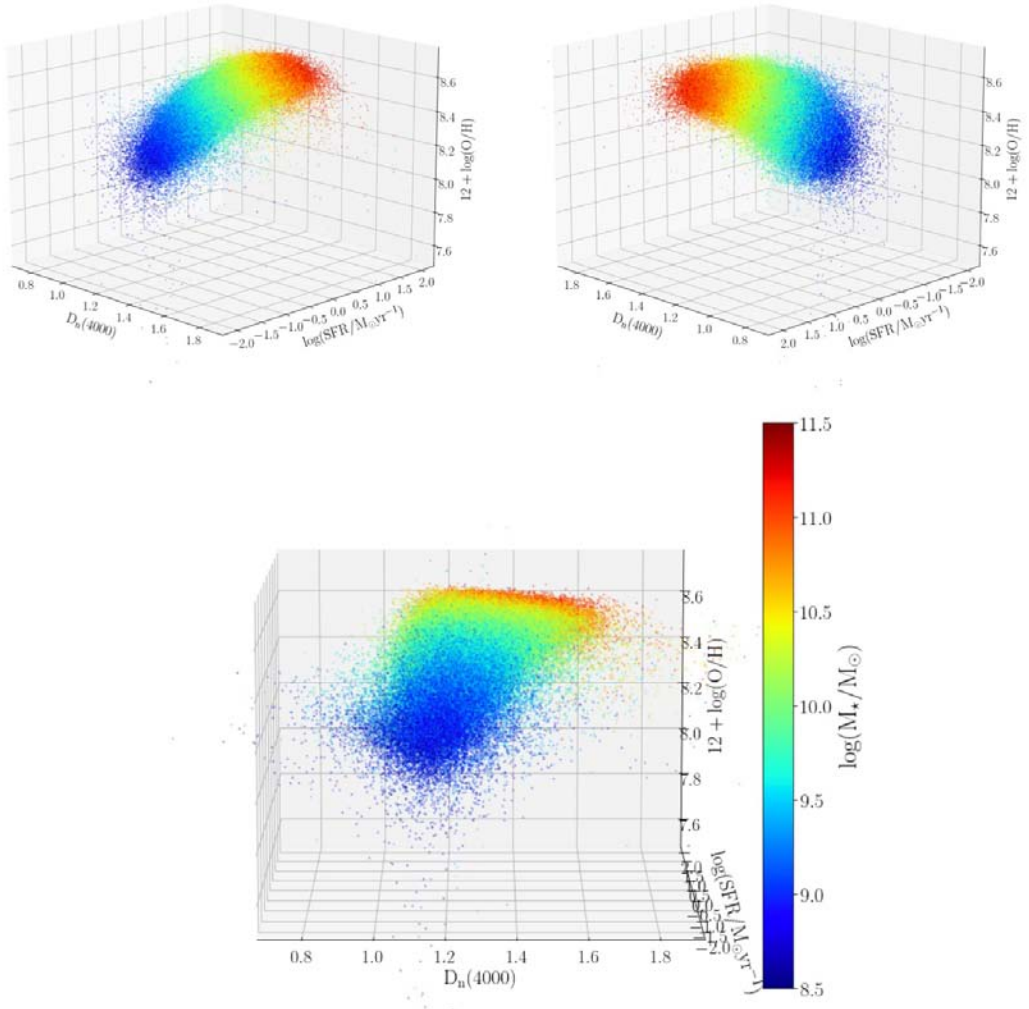


Fig. 8. Population box ($D_n(4000)$ – SFR – 12+log(O/H) diagram) for our sample of star-forming galaxies colour coded by $M_\star$.

Population Boxes

for

All SDSS Star Forming Galaxies

Duarte Puertas, Vilchez, Iglesias-Páramo et al.
A&A 2022. in press.

Astronomy & Astrophysics manuscript no. sf_galaxies
May 4, 2022

Mass-Metallicity and Star Formation Rate in Galaxies: a complex relation tuned to stellar age⋆

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Main results

Negative oxygen abundance gradients confirmed for the large majority of galaxies.
Median values of O/H gradients between -0.06 and -0.03 dex=Re.

Median value of the N/O gradient slope is also negative:
Between -0.12 dex/Re (R calibration) and -0.18 dex/Re (HCm)

O/H gradient slopes correlate with galaxy stellar mass.
This **relation is very non-linear: steepest average gradients around log($M/M_{\odot}$) ~10** with ç flatter average gradients for higher and lower masses, confirming recent findings.

The **N/O gradient versus the stellar mass is non-linear relation.**
Steepest average gradients found for **intermediate galaxy masses**;
flatter at **high mass, BUT flattest gradients for low-mass** galaxies.

Massive galaxies **[log($M/M_{\odot}$)>10.25] => no significant correlation between**
O/H or N/O gradients and mean stellar age [D(4000) index].

For **lower masses => O/H gradients are steeper *for intermediate values of D(4000)***
and they are *flatter for low and high values of D(4000).*

Take-home message

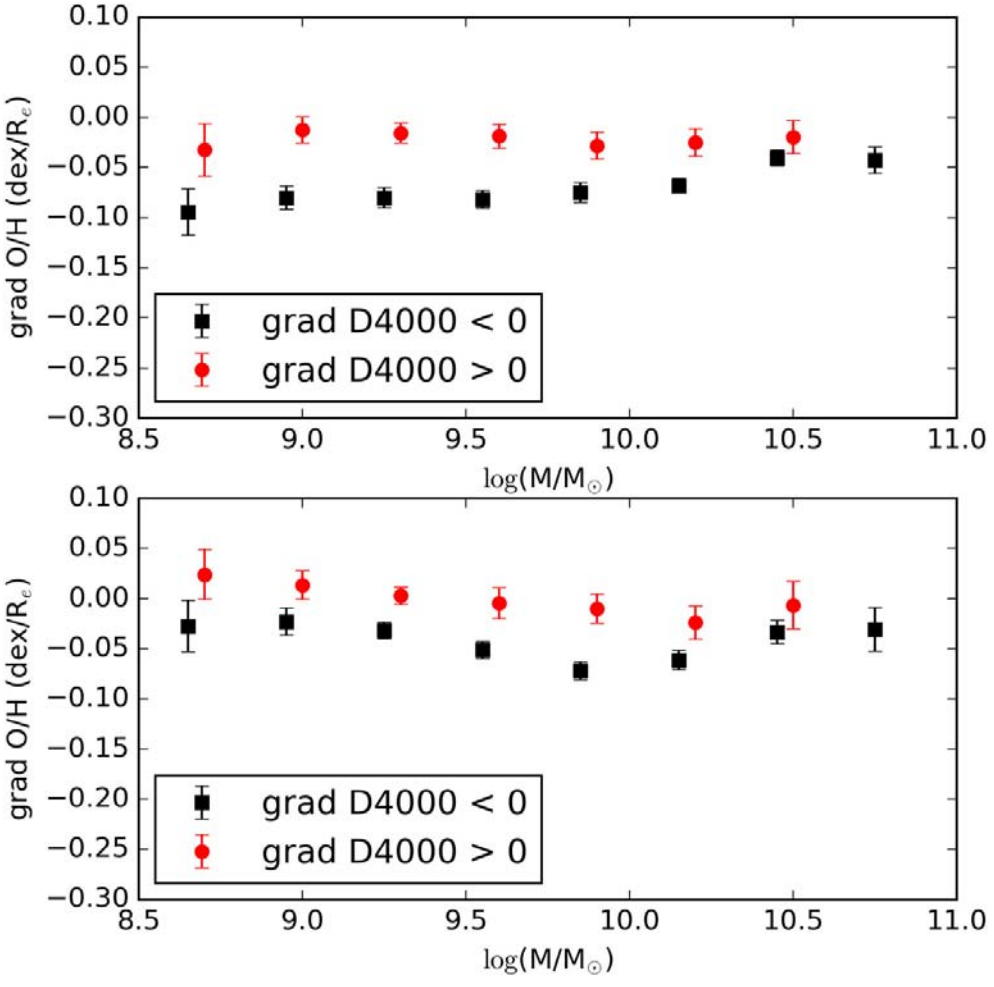
The slopes of the O/H and N/O gradients are, on average, ***flatter in galaxies with a positive D(4000) gradient***, ***as compared to those with a negative D(4000) gradient***.

We interpret the observed behaviour as an ***evolution of the abundance gradient with the age of the stellar population***:

> Young stellar systems tend to have a flat oxygen abundance gradient, which becomes steeper with time up to a mínimum. After this point the oxygen abundance gradient again becomes flatter with time.

This scenario would be naturally expected from inside-out growth of galactic discs.


Thank you!
¡GRACIAS!


0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
−0.30
grad O/H (dex/R$_e$)
grad D4000 < 0
grad D4000 > 0
8.5
9.0
9.5
10.0
10.5
11.0
log(M/M$_\odot$)
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
−0.30
grad O/H (dex/R$_e$)
grad D4000 < 0
grad D4000 > 0
8.5
9.0
9.5
10.0
10.5
11.0
log(M/M$_\odot$)

N/O Gradients vs. Stellar Mass

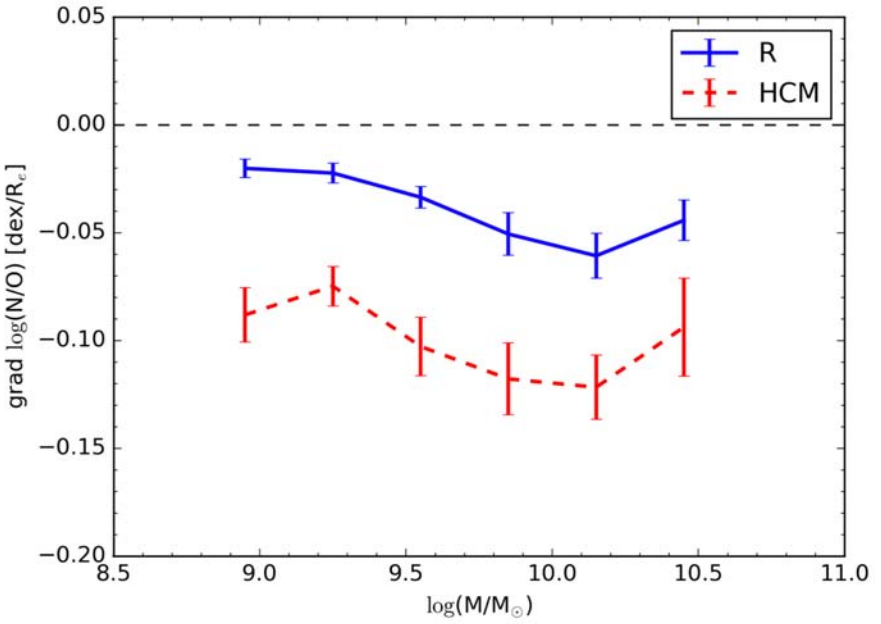
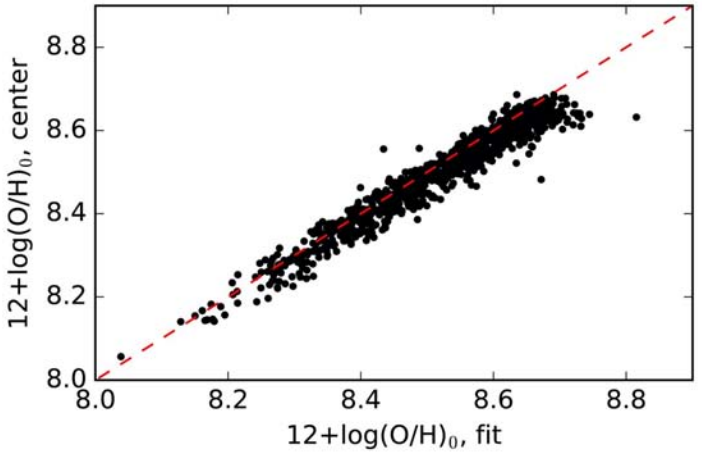
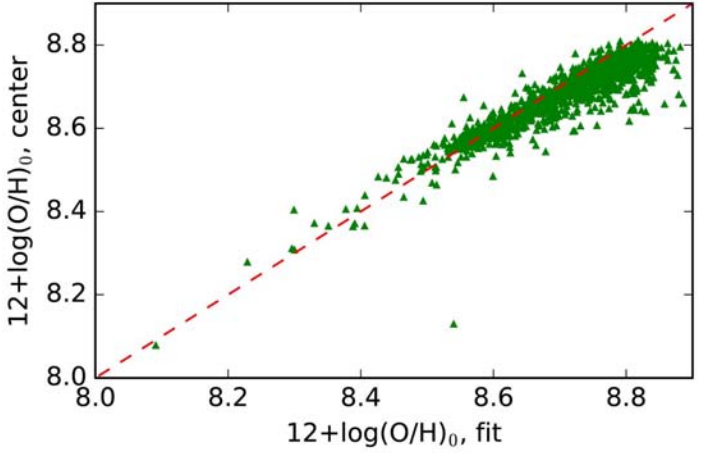


Fig. 6. Median N/O ratio gradient as a function of the galaxy mass for a sample of galaxies with a flat oxygen abundance gradient. The abundances are either derived from the R calibration (blue solid) or using the HCM method (red dashed). Error bars show the standard deviation divided by the square root of the number of data points in each mass bin. For reference, a horizontal dashed line shows the zero level of the N/O ratio gradient.



R



HII-CHI-Mistry