The "MARTA" survey: An in-depth characterisation of electron temperatures, metallicity and ISM properties in z~2-3 galaxies

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INTRODUCTION

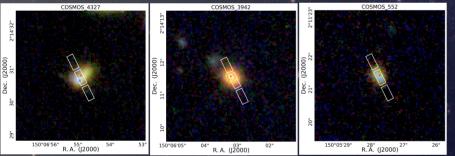
Chemical abundances are crucial tools in our understanding of the processes driving galaxy evolution, but their accurate determination in high redshift galaxies has always been extremely challenging.

The high sensitivity of the NIRSpec instrument on the James Webb Space Telescope (JWST) now enables to detect the faint auroral lines required to perform more 'direct', physically motivated metallicity measurements via the Te method in individual high-z sources, and had completely revolutionised the landscape of chemical abundance studies in the early Universe. Studying the z~2-3 range is particularly interesting because it traces the so called Cosmic Noon, the epoch in which star formation activity reached its peak. This period is critical for understanding galaxy formation and evolution because it represents the time when many of the stars in present-day galaxies were formed.

THE SURVEY

The dataset is based on the MARTA survey: 'Measuring Abundances at high Redshift with the Te Approach', a deep NIRSpec/MSA JWST GO programme aimed at delivering simultaneous, high signal-to-noise detections of rest-frame optical emission lines, including multiple temperature-sensitive auroral lines like [O III]4363, [O II]7320,30, and [S III]6312, in individual spectra of $z\sim2-3$ galaxies.

Here, we present the analysis of 7 galaxies, selected from the MARTA parent sample, with simultaneous detection of [O II]7320,30 and [O III]4363 auroral lines.



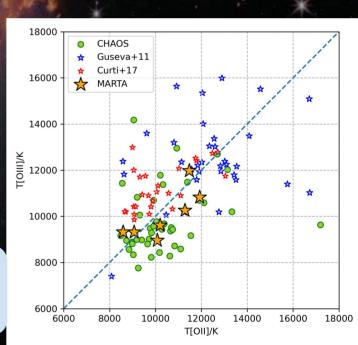
False colour RGB image of three of the analysed galaxies. The position and relative orientation of the three-shutters NIRSpec slitlet is shown

t2-t3 RELATION

The electron temperature of the [O II] and [O III] gaseous zones in galaxies, denoted as t2 and t3 respectively, play a crucial role in determining galactic metallicities through the Te method. Therefore, a t2-t3 calibration is valuable as it allows inferring the other temperature when only one is measured.

In our analysis of 7 galaxies from the MARTA catalog, we compared their t2-t3 relation with Local Universe galaxies (Guseva+11, Curti+17, Berg+20). Our findings suggest no significant evolution of such a relation with redshift, implying that the Te method can be applied similarly to $z\sim2-3$ galaxies as in local HII regions.

> t2-t3 relation of the 7 selected galaxies from MARTA parent sample, compared with galaxies from Local Universe: some scatter from previous relation ,but no clear z evolution

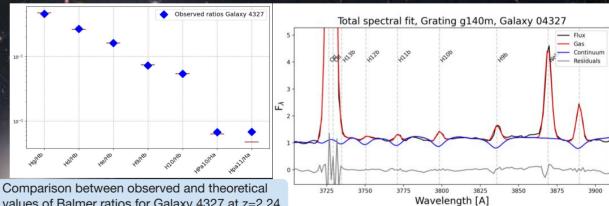


BALMER DECREMENTS

Balmer ratios are the intensity ratios of emission lines in the Balmer series of hydrogen, such as $H\alpha/H\beta$, $H\gamma$, $H\delta$ and so on. Given that in a dust-free environment the Balmer ratios have well-defined theoretical values based on atomic physics, they are fundamental for dust correction, providing a diagnostic tool for measuring the amount of interstellar dust extinction.

Here we show an example galaxy (ID4327 at z=2.24)

values of Balmer ratios for Galaxy 4327 at z=2.24 demonstrating the detection of high-order Balmer lines (up to H12) together with high-order Paschen lines such as Paschen 10. It's interesting to notice is that the ratios obtained for this galaxy are compatible, within the error bars, with the theoretical values i.e. the case of no dust extinction.



PPXF fit of blue grating spectrum for galaxy 4327; the red line corresponds to gas emission lines fit. We underline the presence of high-order Balmer lines

CONCLUSIONS

This study examines z~2-3 galaxies, crucial for understanding the peak star formation activity during Cosmic Noon. The analysis of 7 galaxies from the MARTA survey shows that their t2-t3 relation for electron temperatures is consistent with that of Local Universe galaxies. This indicates that the Te method for determining metallicity can be applied similarly across different epochs. Additionally, we could observe high-order Balmer lines in our galaxies spectra. These findings enhance our understanding of galaxy formation and evolution during Early Universe, demonstrating the effectiveness of JWST in revolutionising chemical abundances studies.