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# Properties of the spatially resolved galaxies in the miniJPAS survey

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## Abstract

The miniJPAS survey is a 1 deg$^2$ survey that, using the same photometric filter system as the Javalambre Physics of the Accelerating Universe Astrophysical Survey (J-PAS), has served to show the scientific capabilities of the latter and to exploit the first scientific results of the filter system. The combination of its 56 narrow and medium band filters and the large field of view of the optical system (0.27 deg$^2$) provides excellent data for the study of the role of the environment in galaxy evolution, as well as for performing IFU-like studies. In this work, we take advantage of these capabilities to study the role of the environment in galaxy evolution at a local scale. For such purpose, we have developed a tool to automatise the complete analysis of the spatially resolved galaxies. We apply this tool to a total of 51 galaxies, divided into 9 red galaxies in groups, 15 red galaxies in the field, 6 blue galaxies in groups, 21 blue galaxies in the field. We study the radial profiles of the stellar population properties and the distribution of the emission lines in an stellar mass density-colour diagram. Our results are compatible with an inside-out formation and quenching scenario, and they show a clear distinction between red and blue galaxies, but no significant effect of the environment.

## 1 Introduction

The bi-modality of galaxies (see e.g. [3, 35, 11]) and the increase in the fraction of red galaxies since $z \sim 1$ is usually attributed to the truncation of the star formation of blue galaxies, mostly with masses lower than $10^{10}$ M$_\odot$ (see e.g. [12]). Since the fraction of galaxies in the green valley is not enough to explain these observations [3, 18, 36], the concept of quenching has been proposed as a mechanism responsible of this cessation of the star formation [18, 38, 39] and is usually divided in to mass quenching and environmental quenching [38, 39].

The environment is proposed as a source of quenching since galaxies in dense environments, such as galaxy clusters and galaxy groups, undergo interactions among them and between them and the inter-galactic medium (IGM), which can lead to processes that remove or heat the gas from galaxies, preventing further star formation, such as ram-pressure stripping [26], tidal stripping [30], or harassment [34]. In addition, the galaxy populations and the properties of galaxies in dense environments are different than those in the field (see e.g. [8, 16, 2, 27, 25, 41] and references therein).

The consequences of these processes might also be appreciated at local scale (see e.g. [5, 9, 17] and references therein). In this regard, IFU-like surveys, such as CALIFA [42] or MaNGA [7], have played a crucial role, as well as in understanding the formation and evolution of galaxies at local scale (see e.g. [19, 23, 24, 5] and references therein).

The Javalambre Physics of the Accelerating Universe Astrophysical Survey (J-PAS [4]), survey is an ongoing survey that will scan thousands of square degrees of the Northen sky, using the JT250, a 2.55 m telescope located at the Observatorio Astrofísico de Javalambre (OAJ). In the meantime, the miniJPAS survey [6] has already provided data for 1 $\deg^2$ using the same telescope and photometric filter system as J-PAS. This system consists of 54 narrowband filters, with a Full Width Half Maximum (FWHM) of 145 Å, equally spaced every 100 Å, providing full coverage over the optical wavelength range, from 3780 Å to 9100 Å, with an spectral resolution of R$\sim$ 60. This filter system allows retrieving the stellar population properties (SPP) of galaxies by fitting their Spectral Energy Distribution (SED) [22], as well as the estimation of the emission lines of galaxies (see [31, 32]). Additionally, the large FoV of the optical system (0.27 $\deg^2$) provides unbiased detection of galaxy clusters and groups [15, 33], and has been used to study the role of the environment in integrated galaxies [25, 41]. The combination of these two capabilities make miniJPAS an excellent survey to perform IFU-like studies. In this work, we aim at using this potential to study the role of environment on galaxy evolution at a local scale.

## 2 Data

All the data used in this work belongs to the miniJPAS survey [6]. We select the galaxies in the catalogue that are spatially resolved by imposing the following conditions: i) The effective radius (R_EFF, provided by `SExtractor`) of the galaxy must be larger than $2''$, given the typical FWHM of the Point Spread Function (PSF) of the images in miniJPAS (see Fig. 5 in [6]); ii) The radius obtained as the square root of the isophotal area divided by $\pi$ must be at least two times larger than the FWHM of the PSF; iii) The ellipticity must be smaller than 0.6, to avoid galaxies that are not sufficiently face-on; iv) The `MASK_FLAGS` parameter provided by `SExtractor` must be 0 for all the filters; v) The `FLAGS` parameter must not contain the flag 1 (objects with biased photometry); vi) The `CLASS_STAR` parameter must be lower than 0.1, to filter the maximum number of stellar objects. These criteria give us a total of 51 galaxies to study.

Since our goal is to study the effect of the environment on galaxy evolution, we classify galaxies by spectral type and environment. For the first classification, we use the equation by [14], adapted from [11] to the miniJPAS data, to segregate galaxies into red and blue. This criterion, which was also used in [22, 25, 41] classifies galaxies to be red if $(u-r)_{\mathrm{int}} > 0.16(\log(M_\star)-10)-0.254(z-0.1)+1.689$, and blue otherwise. In order to classify galaxies by their environment, we use the galaxy groups and cluster catalogues by [33]. These catalogues provide a probabilistic association for each galaxy to be a member of a cluster or group detection. We follow the same criterion as [25], selecting as galaxies in groups those with a probabilistic association $P_{\mathrm{assoc}} > 0.7$ and those with $P_{\mathrm{assoc}} < 0.1$ as galaxies in the field. With these criteria, our sample is divided into 9 red galaxies in groups, 15 red galaxies in the field, 6 blue galaxies in groups, 21 blue galaxies in the field.

# 3 Methodology

We use `Py2DJPAS`, our tool that automatises all the steps required for the analysis of the spatially resolved galaxies, which includes the download of all the required scientific tables and images, the masking and PSF homogenisation of the images, the definition of the regions, and the calculations of the magnitudes, using the calibration by [28, 29]. This code will be explained in detail in an upcoming paper (Rodríguez-Martín et al., in prep.). For this work, we use elliptical rings of 0.7 `R_EFF`, in order to provide an homogeneous division of the galaxies, given the size of the smallest galaxies Compared to the PSF. The parameters of the ellipses were obtained using the routine from PyCASSO [10]. Additionally, we remove from our analysis those regions with median S/N $< 5$ in the filters with $\lambda_{\mathrm{pivot}} < 5000$, because these filters contain the information regarding the 4000-break, which correlates with many SP properties (see e.g. [20]), and the low S/N can lead to incorrect results.

In order to retrieve the SP properties of the galaxies and their regions, we use the SED-fitting code `BaySeAGal`. This is a parametric code that uses a Markov Chain Monte Carlo (MCMC) approach, which allows us to estimate the values of the SPP and their error. We assume a $\tau$-delayed star formation history (SFH), as we did in [22, 25, 41]

We use the Artificial Neural Networks trained by [31] to estimate the equivalent widths and ratios of the H$\alpha$, H$\beta$, [NII] and [OIII] emission lines. These ANN were also used by [32] to characterise the emission line galaxy (ELG) population in miniJPAS.

# 4 Results

Our results can be mainly divided into two main categories: those regarding the SPP and those related to the emission lines. We show the radial profiles of the SPP in Fig. 1, divided by spectral type and by environment. These results show decreasing profiles of the stellar mass density ($\mu_\star$), the stellar metallicity, the $(\mathrm{u}-\mathrm{r})_{int}$ colour, and the intensity of the star formation rate ($\Sigma_{\mathrm{SFR}}$) for every type of galaxy. The age profiles of red galaxies are flat, while blue galaxies tend to show younger stellar populations in their outer regions. The extinction profiles show a similar behaviour to the ages. The specific star formation rate

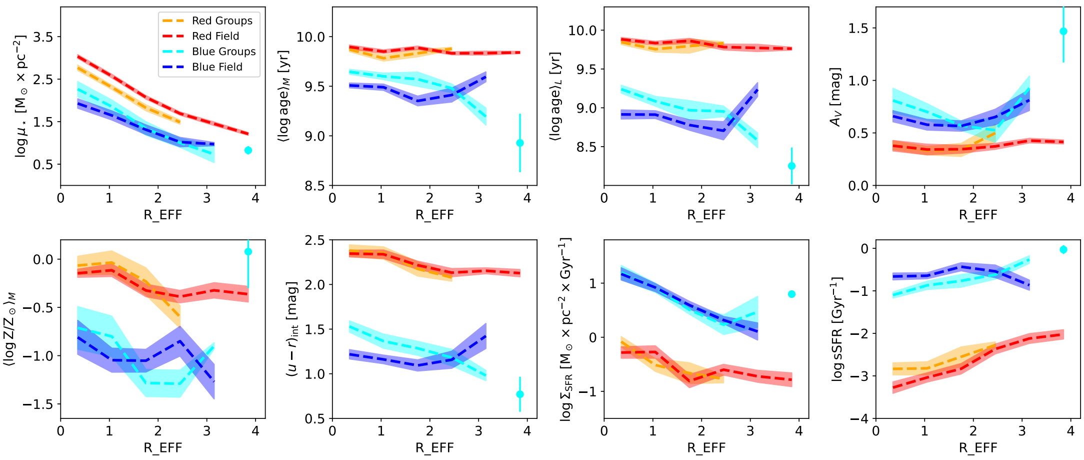


Figure 1: Radial profiles of the SPP of the galaxies in the sample. From left to right, up to bottom, $\mu_\star$, mass-weighted age, luminosity-weighted age, extinction $A_V$, stellar metallicity, $(u-r)_{\rm int}$ colour, $\Sigma_{\rm SFR}$, and sSFR. Dashed lines represent the median value of the property at a given distance. Colour shadows represent the error of the median. Single points represent bins were only a single point was available for that distance and spectral type. Orange, red, cyan, and blue colours represent red galaxies in groups, red galaxies in the field, blue galaxies in groups, and blue galaxies in the field, respectively.

(sSFR) increases towards outer regions.

These profiles suggest an inside-out formation and quenching scenario. Our results, including the values of the properties for a given spectral type, at a given distance to the galactic centre, are compatible with those of other works in the literature, such as [21, 24, 5, 37, 9]. Additionally, red and blue galaxies are clearly differentiated, but our results show no significant effect of the environment on the radial profiles. This could be due to the low mass of the galaxy groups hosting the galaxies, since their mass is generally low (the total stellar mass of groups containing blue galaxies is $10^{10.25}$–$10^{11.5}$ $M_\odot$, and the total stellar mass of groups containing red galaxies is $\sim 10^{10.75}$–$10^{12}$ $M_\odot$), and some environment-related processes are known to be more intense in high-mass structures (see e.g. [1, 40]). In particular, we already showed, using the miniJPAS data, that the cluster environment is more effective at quenching the star formation than the group environment [25].

In order to study the emission lines, we use stellar mass density-colour diagrams (see Fig. 2), which are analogue to integrated mass-colour diagrams we used in [22, 41]. We find that the equivalent width (EW) of the H$\alpha$, H$\beta$, [NII] and [OIII] emission lines are clearly distributed in the mass density–colour diagrams, with the highest EW generally found in the lowest density, bluest regions. The ration of [NII]/H$\alpha$ is also clearly distributed in this diagram, with the highest ratio found in the reddest and densest regions. Given the strong relation of the properties with $\mu_\star$ and the colour, we do not find an indication of a dependency of the emission lines with the environment.

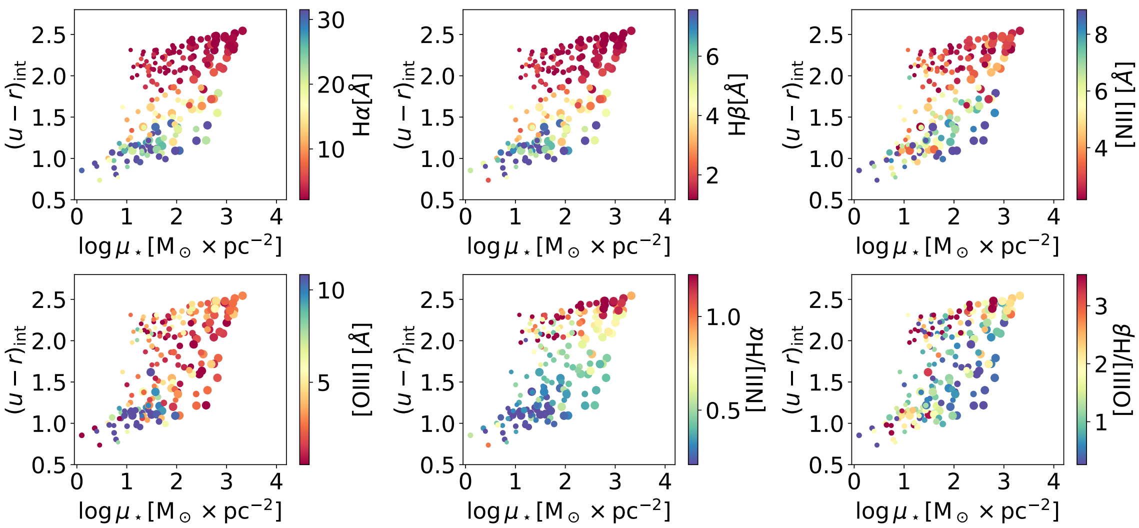


Figure 2: Stellar mass density-colour diagrams of the regions. From left to right, up to bottom, colour codes represent the EW of H$\alpha$, H$\beta$, [NII], and [OIII], and the ratios [NII]/H$\alpha$ and [OIII]/H$\beta$. Point size is inversely proportional to the centre of the galaxy.


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