*Resolving the Rise and Fall of Star Formation in Galaxies*
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# Variable metallicity yields as tracers of inflows

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**Abstract.** Pristine gas accretion is expected to be the main driver of sustained star formation in galaxies. We measure the required amount of accreted gas at each moment over a galaxy's history to produce the observed metallicity at that time given its star-forming history. More massive galaxies tend to have higher accretion rates and a larger drop of the accretion rate towards the present time. Within the same mass bin galaxies that are currently star-forming or in the Green Valley have similar, sustained, accretion histories while retired galaxies had a steep decline in the past. Plotting the T80 of the individual accretion histories, a measure of how sustained they are, versus the stellar mass and current sSFR we see a distribution such that currently star-forming galaxies have sustained or recent accretion and retired galaxies have declined accretion histories.

**Keywords.** galaxies: abundances, galaxies: evolution, techniques: spectroscopic

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## 1. Introduction

The chemical enrichment history (ChEH) of a galaxy is the result of the net effect of the competing processes of enrichment and dilution that act on the interstellar medium over its lifetime. The enrichment is driven by the stellar population as they produce the elements and disperse them as they evolve and die. This input is balanced by the ISM interacting with its surroundings via accretion of pristine gas from the surroundings and outflows driven by stellar winds and AGN (Lilly et al. 2013).

As a simplified model, we can therefore consider the ChEH to be the result of the star-formation history (SFH) and the dilution history. We have measured the ChEH and SFH of MaNGA galaxies in a previous work (Camps-Fariña et al. 2022) which allows us to measure the dilution history by comparing the input of metals from the SFH to the measured ChEH. Pristine gas accretion is considered to be the key mechanism sustaining star-formation in galaxies (Sánchez Almeida et al. 2014).

## 2. Analysis

The ChEHs and SFHs were obtained by fitting the stellar spectra of galaxies in the MaNGA sample with a stellar population synthesis code, PyPipe3D (Lacerda et al. 2022). The MaNGA survey (Bundy et al. 2015) consists of IFU observations of ∼10,000 galaxies in the local universe providing spatially resolved spectroscopic information with a typical spectral resolution of ∼2000 over a wavelength range 3600-10300Å and an effective spatial resolution of ∼2.5". The fitting code uses templates of spectra of populations of stars of

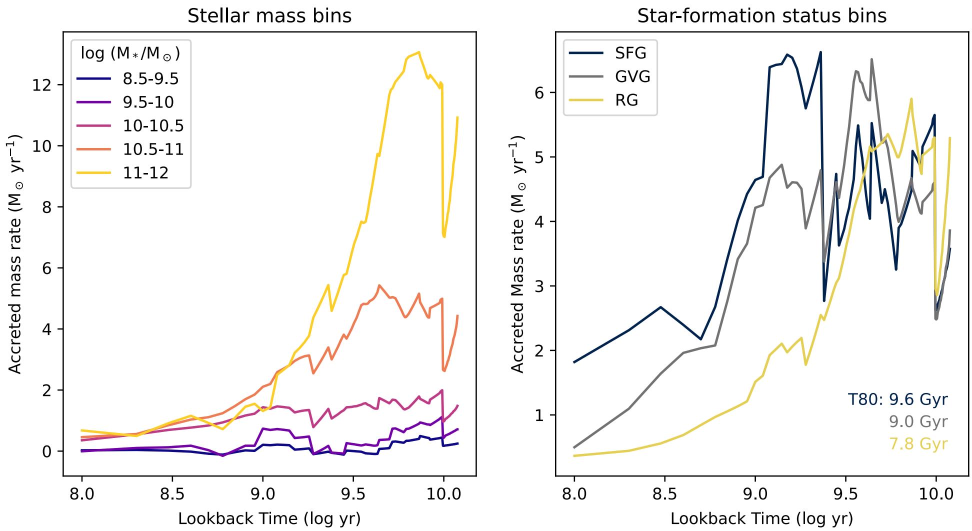


**Figure 1.** Pristine gas accretion histories for the galaxies in our sample. In the left panel the galaxies are divided into stellar mass bins. In the right panel a single stellar mass bin is considered: $10^{10.5-11}$ $M_{\odot}$ and the galaxies are further subdivided into current star-formation status mass bins using $EW_{H\alpha}$: Star-forming (SFG), Green Valley (GVG) and Retired (RG) galaxies. In the bottom right of the right panel we show the T80 of the accretion history defined as the time it takes to accrete 80% of the total accreted gas mass.

known age and metallicity values to recover the weights of each population allowing for the determination of the ChEH and SFH (Camps-Fariña et al. 2022).

The conversion from SFH to metal injection over time is done using a modified version of the galaxy chemical evolution code from Roca-Fàbrega et al. (2021) which was used to explain the distribution of Li abundance in the Milky Way as a result of a particular SFH and accretion history. In this work we treat the ChEH as an input rather than an output.

## 3. Results

In Figure 1 we show the resulting pristine gas accretion histories for the galaxies in the MaNGA sample divided into mass and star-formation status bins. The methodology to obtain these histories is to take the averaged ChEH and SFH of each stellar mass and star-forming status bins and calculate the necessary accretion history using the chemical evolution code. The histories correspond to those of Figures 3 and 5 from Camps-Fariña et al. (2022). The stellar mass bins are selected from current values of the mass and the current star-formation status bins are defined from the $EW_{H\alpha}$ with 3Å and 10Å as the boundary values.

The accretion histories show how more massive galaxies tend to accrete more gas over their lifetime compared to less massive ones. The former also show a more pronounced peak in the accretion rate such that they have suffered a significant decline in their accretion rate compared to early epochs.

If we control for stellar mass, however, we also see a difference in the accretion histories of galaxies depending on their current state of star-formation. In the right panel we show the histories within a single mass bin, $10^{10.5-11}$ $M_{\odot}$ but further divided into bins defined by their current star formation. Retired galaxies show a declined accretion history which is different from star-forming and Green Valley (GV) ones. The latter two have very similar histories until about 500 Myr ago (log LBT ∼8.7) when Green Valley galaxies

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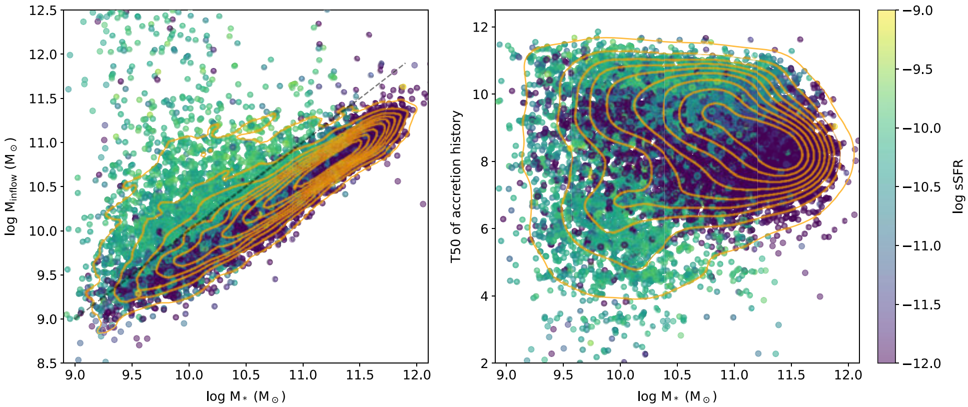


**Figure 2.** In the left panel, the correlation between the stellar mass and the total accreted gas mass. In the right panel, the correlation between the stellar mass and the T80 of the accretion history, defined as the time it takes to accrete 80% of the total accreted gas mass. In both panels the color of the points shows the sSFR and the orange contours the density of points.

have a drop in accretion rate. The similarity of star-forming and GV galaxies fits very well with our expectations as the latter are only now stopping their star-formation so they should have a similar history until recently.

### 3.1. *Individual histories*

The previous results were obtained using averaged ChEHs and SFHs but we can also calculate the gas accretion histories of each galaxy in the sample and study what correlations arise from their defining parameters.

In Figure 2 we show the correlation between stellar mass, sSFR, and either the total accreted gas mass or the T80 of the accretion history. The latter corresponds to the time it takes for 80% of the total mass to be accreted and is an indicator of whether the accretion is sustained or recent (high T80) or whether it has declined (low T80).

The left panel shows a tight correlation between the stellar mass and the accreted gas mass with currently star-forming galaxies located in an upper envelope of the accreted gas mass such that currently star-forming galaxieas have accreted more pristine gas.

In the right panel the main region shows a correlation such that for each stellar mass galaxies which are currently star-forming have more sustained or recent accretion. This figure is similar to the SFR-M$_*$ plane, with a distribution of high-mass, retired galaxies and a tighter sequence of star-forming galaxies. This allows us to predict whether a galaxy is currently star-forming based on the shape of its chemical balance.

Given the relative simplicity of the approach this method could become a valuable tool to evaluate and validate galaxy evolution models and simulations, especially if the chemical evolution code is improved to include more complex dilution mechanisms and the effect of outflows.

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