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The SFH of Fornax S0 galaxies through their stellar populations

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I present the first results of a stellar population study (central and gradients) for a sample of S0 galaxies in the Fornax cluster. The sample covers a wide range in galaxy mass, while the VLT-FORS2 spectroscopy reach farther than 1 effective radius ($1\,R_{HALF}$) from the nucleus of the galaxies.

Keywords: S0 galaxies; Stellar populations; Evolution

1 Introduction

I found that the star formation history of Fornax S0s is strongly dependent on galaxy mass. These findings are consistent with no unique mechanism being responsible for the evolution of Fornax S0s as a Hubble type. The evidence from their stellar populations favors rather varied and stochastic processes behind their evolution. The bulges of Bright Fornax S0s ($M_B < -19$) show stellar population properties consistent with the major merger scenario. The last of those events took place long ago ($\approx 10\,Gyr$) in agreement with local bright ellipticals (E) and early-type spiral bulges. Intermediate Fornax S0s ($-19 < M_B < -18$) are not consistent with a solely passive spiral fading scenario. Apart of disk fading, a central enhancement of star formation is required before quenching. External accretions of material are purposed as a possible mechanism to induce a central starburst. Faint Fornax S0s ($M_B > -18$) are plausible candidates to be the direct descendants of late-type, purely faded spirals. More data is required to know whether these results (and their interpretation) are representative of the entire S0 class.

2 Age and metallicity calculation with MILES

I estimate the simple stellar population (SSP) ages and metallicities ([M/H]) by using the new models of Vazdekis et al. [1] based on MILES stellar library [2]. One of the

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most remarkable advantages of using MILES is its much higher spectral resolution compared with the original Lick/IDS library. Such improvement allows us to work at the resolution of the data in many cases, degrading the SSP models to the resolution of the galaxy spectra. In this way, I can directly compare the SSP of different galaxies at different radii without degrading the spectra in function of its local velocity dispersion. An example is shown in Fig. 1.

3 Central ages and metallicities

In Fig. 2 top panel, I compare the central indices of the sample galaxies with data from the SAURON collaboration [3]. Over this Index–Index diagram I plot an SSP model grid of Vaz10 in order to compare relative ages and [M/H].

Bright Fornax S0s ($M_{\rm B} < -19$; 3 objects: black circle, square and cross in bottom-right section of model grid) are in the same region as SAURON Es and early-type spiral bulges (small grey triangles and asterisks, respectively), being old and [M/H]-rich. These results are also consistent with the nuclei data from a sample of 58 S0s from different environments [4]. That sample, like bright Fornax S0s, is dominated by relatively high velocity dispersion galaxies ($> 120\,{\rm km\,s^{-1}}$). Intermediate Fornax S0s ($-19 < M_{\rm B} < -18$; 3 objects: diamond, '×' and triangle in top-right section of model grid) are younger and metal rich. Even though their central ages and α-enhancements (2 Gyr and solar abundance, respectively) agree with SAURON late-type spirals (small squares), the latter are clearly metal-poorer than the intermediate Fornax S0s. This solely [M/H] variation between the two galaxy types would not be consistent with the pure, spiral passive fading scenario. The Faint Fornax S0s ($M_{\rm B} > -18$; 3 objects: triangle, asterix and cross in left half of model grid) are usually old and [M/H]-poor. Their [M/H]s are in excellent agreement with SAURON late-type spirals ([M/H] < -0.40). The sole age variation between the two galaxy types makes an evolution path plausible where bulges of late type spirals passively fade to become faint S0s like those in our sample.

4 Gradients in age, metallicity and α-abundance tracer

When a significant positive or negative gradient is detected, it is usually strongly driven by the central region of the bulge-dominated galaxy component. Therefore, from this point of view, the significant (non zero) gradients could be interpreted as inner-bulge dominated features. In many cases, even before reaching $1\,{\rm R_{HALF}}$, most gradients look already fairly flat (see [9] for more details). In the following paragraphs I make some references concerning gradients and 'bulges' or 'central regions' of galaxies. They must be understood as above stated.

In Fig. 2 bottom panel, I show an example of the gradients in age, [M/H] and α-abundance tracer ($[{\rm M/H}]_{\rm Mgb} - [{\rm M/H}]_{<{\rm Fe}>}$, the metallicity difference derived from a Mg-sensitive index, e.g. Mg*b*, and a Fe-sensitive index, e.g. $<$ Fe $>$; see Vaz10) measured in the S0 sample. The [M/H] gradients of old, Bright Fornax S0s (NGC 1380 and 1381; ≈ -0.2) agree with mean estimations derived from the literature for bright

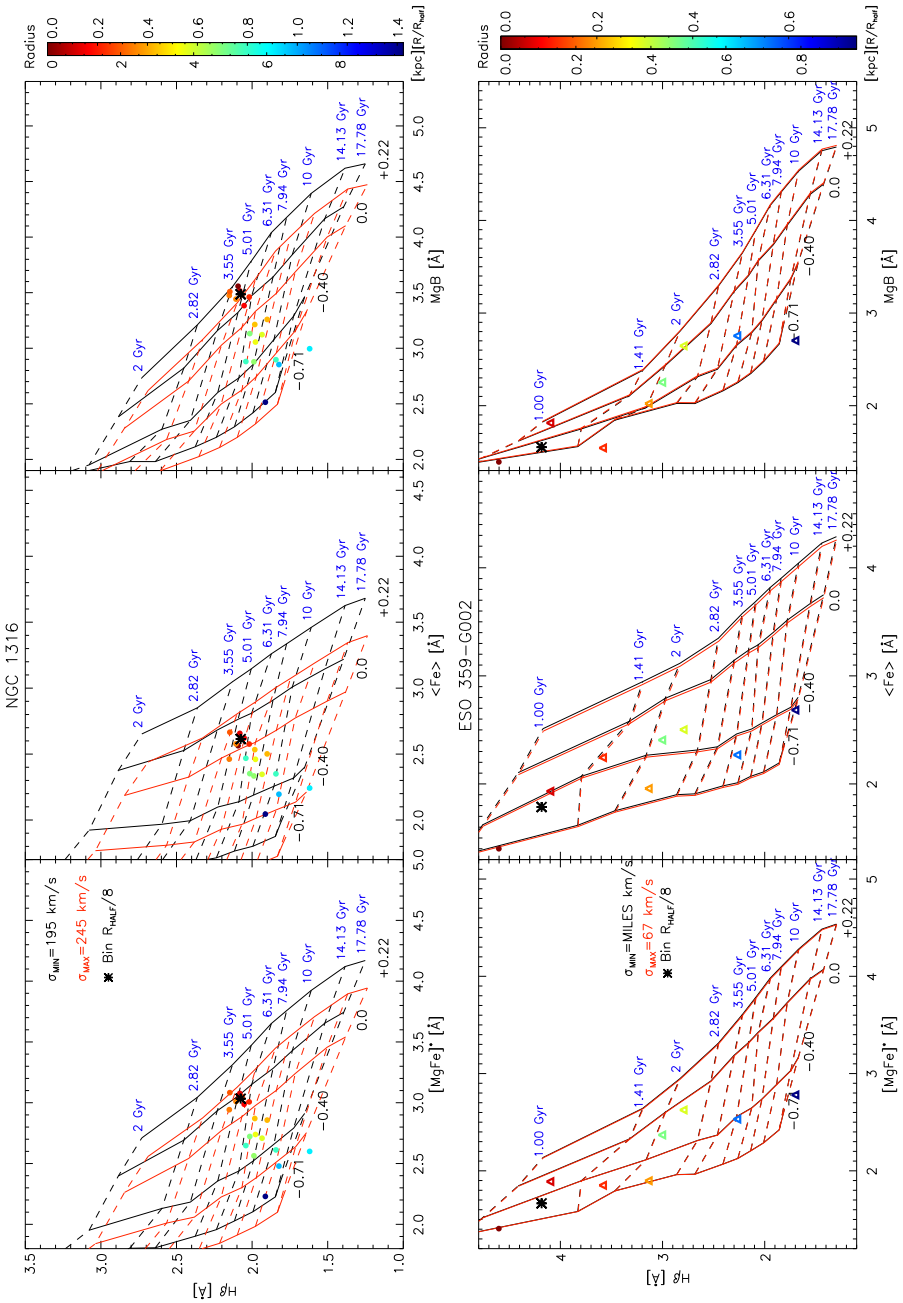


Figure 1 Examples of NGC 1316 and ESO 359-G002 radial data with SSP model grids from [1]. Hβ is used as the age-sensitive index, while [MgFe]$'$ (left), $<$ Fe $>$ (center) and Mgb (right) are used as [M/H]-sensitive indicators. Color code on galaxy data represents the radial distance of each data point. The asterisks represent the central measurements (within $R_{HALF}/8$). For clarity, only two model grids are shown, those with the higher (grey) and lower (black) local galaxy velocity dispersion.

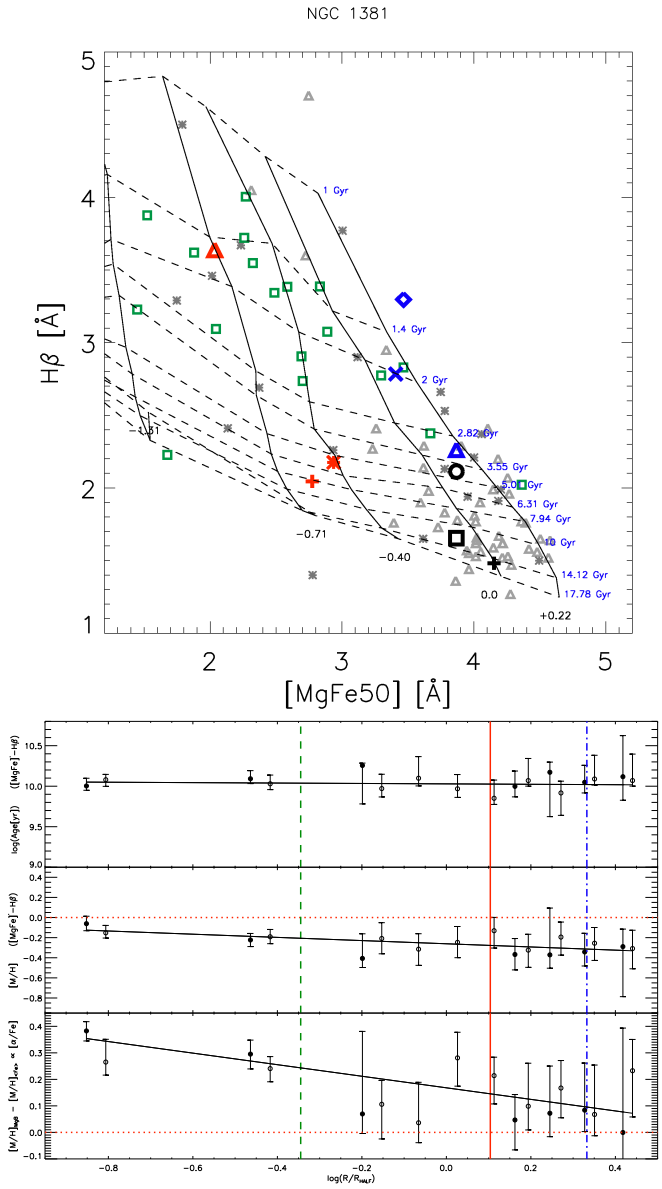


Figure 2 *Top:* Central Hβ vs. the combined [MgFe50] index for the S0 sample and data from SAURON [3]. A SSP model grid from [1] is also shown. Models and indices are at Lick resolution to resemble SAURON data. Bright, Intermediate and Faint S0s shown in different large symbols (see text). Es and early-type spirals from SAURON in small triangles and asterisks, respectively. Late-type spirals from SAURON, in small squares. *Bottom:* Age, [M/H] and α-abundance tracer gradients of NGC 1381, one of the bright S0s of the sample. Continuous line fits show the gradients of the radial profiles. The horizontal dashed lines in [M/H] and [α/Fe]-tracer plots represent solar metallicity and abundance, respectively. The vertical lines show different scale-length radii: bulge effective radius (dashed); disk scale-length (continuous); radius from which the disk dominates light profile (dot-dashed).

E samples and with major merger chemodynamical models. Their negative α-profiles are also consistent with mergers which happened long ago (e.g., [5]) in short time-scales (e.g., S0 nuclei in dense environments from [4]). Therefore, at a first glance, the stellar population gradients of bright Fornax S0 bulges agree with a merger-induced origin. Concerning Intermediate Fornax S0s, their centrally young ages, steep [M/H] gradients, and flat/solar α-profiles are consistent with models where a central starburst compromising 10–30% of the final stellar mass took place few Gyr ago [5].The high incidence of accretions triggering starbursts would be a plausible mechanism [6]. Finally, Faint Fornax S0s gradients are consistent with being flat (within uncertainties). While SAURON late-type spirals show flat α-profiles and a variety of gradients in age (consistent with faint S0s), they have rather strong and negative [M/H] gradients. In principle, the presence of [M/H] gradients in late-type spirals is in odds with the results from faint Fornax S0s. However, in [7] it has been shown for a sample of dwarfs in Fornax cluster that an age difference would explain this apparent inconsistency between [M/H] gradients, in a time interval consistent with our findings in faint S0s ($\approx 3\,\mathrm{Gyr}$). Overall, these results are consistent with a scenario where faint Fornax S0s are direct descendants of purely faded, late-type spirals.

Even though I have shown evidence consistent with different evolutionary paths in Fornax S0s, the small sample and particular environment of these galaxies limits the scope of these results. Certainly, more data is required to address whether these findings (and their interpretation) are representative of the entire S0 class. See [8] and [9] for further details.

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