Resolving the Rise and Fall of Star Formation in Galaxies
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Characterizing star formation in the innermost kiloparsec of the galaxy NGC 1386

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Abstract. We characterize the star formation going on in the inner kiloparsec region of the galaxy NGC 1386 as derived from the analysis of a multiwavelength dataset covering the optical, near-IR and mid-IR at subarsec resolution. We detect 61 point sources, distributed in a ring of 960 pc radius around the center of the galaxy. From SED fitting we conclude that these are low mass ($440 < \mathrm{M}/\mathrm{M}_{\odot} < 79000$) young clusters, with age distributed from 1 to 10 Myr, with median at 3.6 Myr. Comparison of the Hα luminosity of the clusters derived from the Hα+[N II] narrow band image with that expected from the fitted ionizing continuum shows that a large fraction of the ionizing photons escapes from the clusters. Moreover, a large fraction of these photons escapes from the regions around the star forming ring.

Keywords. galaxies: individual NGC1386, galaxies: star formation, galaxies: ISM, methods: data analysis

1. Introduction

We present preliminary results of the star formation properties of the circumnuclear region of NGC 1386, a nearby (15.3 Mpc, Jensen et al. 2003) Sa galaxy. This is part of an ambitious program, "The central parsecs of the nearest galaxies"†)(PARSEC), aimed to determine the physical processes occurring in the inner regions of the nearest galaxies, with particular focus on the relation between the nuclear star formation and its parental molecular gas and dust material (e.g. Prieto et al. (2009)). We use multiwavelength, from optical to near-IR, high angular resolution data that allow us to identify clusters of size ≈ 8 pc, and calculate its age, mass and extinction by fitting its spectral energy distribution with stellar population models.

2. Data

We use near-IR images on *J*, *H*, *Ks* bands, obtained with the AO assisted instrument NaCo, located at the VLT facility in Paranal Observatory, Chile as part of the PARSEC project. To complement IR observations, we use optical images from the HST scientific archive acquired with the Wide-Field Planetary Camera 2 and the Near Infrared Camera

† http://research.iac.es/proyecto/parsec/main/index.php

and Multi-Object Spectrometer with the broad band filters: F547M, F606W, F791W, F814W, F110M, F110W, and the narrow-band filters F656N, F658N, FR656N_1 and FR680N, centred on the emission line Hα+[N II] and its adjacent continuum

3. Model

We use DynBaS (Magris *et al.* 2015) standard spectral energy distribution fitting algorithm, with the assumption that each detected cluster in NGC 1386 is well represented as a single-age and single-metallicity population of stars (SSP) (DynBaS1D), that evolves passively. The SSPs are from the Charlot & Bruzual models as described in Plat et al 2019, computed for the solar metallicity evolutionary tracks of the Padova's group (Bressan et al. 2017). We use a Chabrier (2003) IMF in the standard interval between 0.1 and 100 M$_\odot$. For each cluster, DynBas1D provides the model *age*, *mass*, and A_V that best fit the observed SED and computes the corresponding intrinsic Hα luminosity ($L(\mathrm{H}\alpha)_0^{\mathrm{mod}}$), assuming a complete conversion of the hydrogen ionizing photons.

Due to the low mass derived for the clusters (see Fig. 1), in a range where the initial mass function might not be fully populated, additionally to the standard DynBas fitting we use a stochastic implementation, described in Prieto *et al.* (2022), where we use 1000 SSPs, with a stochastic sampling of the IMF as described in Bruzual (2002).

4. Results

Fig. 1 shows the distribution of the physical quantities derived for the clusters in NGC 1386, and its mutual relations. We find the following results:

• Age: Model age distribution shows clusters in NGC 1386 were mainly formed less than 6 Myr ago, with a median at 3.6 Myr, and a low dispersion (first and third quartiles at 2.75 and 4.3 Myr). We found no evidence of older events of star formation in the innermost part of this galaxy, if ocurred, they must have been of too low mass to be detected at the present.

• Mass: Detected clusters correspond to low mass objects, between 440 and 79000 M$_\odot$ with median at 4100 M$_\odot$. The most massive clusters are found to be the youngest, in the 2 Myr range, with $A_V \approx 3-4$ mag, consistent with young ages being in denser and dustier environments.

• Av: Clusters are mildly extincted with A_V between 0 and 5 mag. A comparison of A_V with the A_V derived from the VLT/Ks-band − HST/F814W image shows a fair agreement (Prieto *et al.* 2022). We find a positive correlation between *mass* and A_V, which we interpret as lower mass clusters are detected only in low dust environment. Also consistent with the fact that only massive clusters are able to retain material from their original cloud (e.g. Tenorio-Tagle et al 1999). However this correlation is not reported in more massive clusters (e.g. Turner et al. 2021) and should be considered to further analysis.

• Hα luminosity: We find the Hα luminosity of the clusters derived from the Hα+[N II] narrow band image is significantly less that expected from the fitted ionizing continuum. Moreover, total $L(\mathrm{H}\alpha)_0^{\mathrm{mod}}$ from clusters exceeds the total measured Hα in the ring (cluster+intracluster emission). This can occur in three non-exclusive scenarios: a fraction of the ionizing photons are locally absorbed within the HII region, and/or the HII regions are matter-bounded, and/or with a covering factor < 1, and the ionizing radiation finds a way to escape from the respective HII region. The consequences of these scenarios on the star formation rate–L(Hα) calibration is presented in Prieto *et al.* (2022).

• Stochasticity: None of the above general results are affected by the fluctuations in the IMF sampling in low mass stellar populations (gray dots and histograms compared with

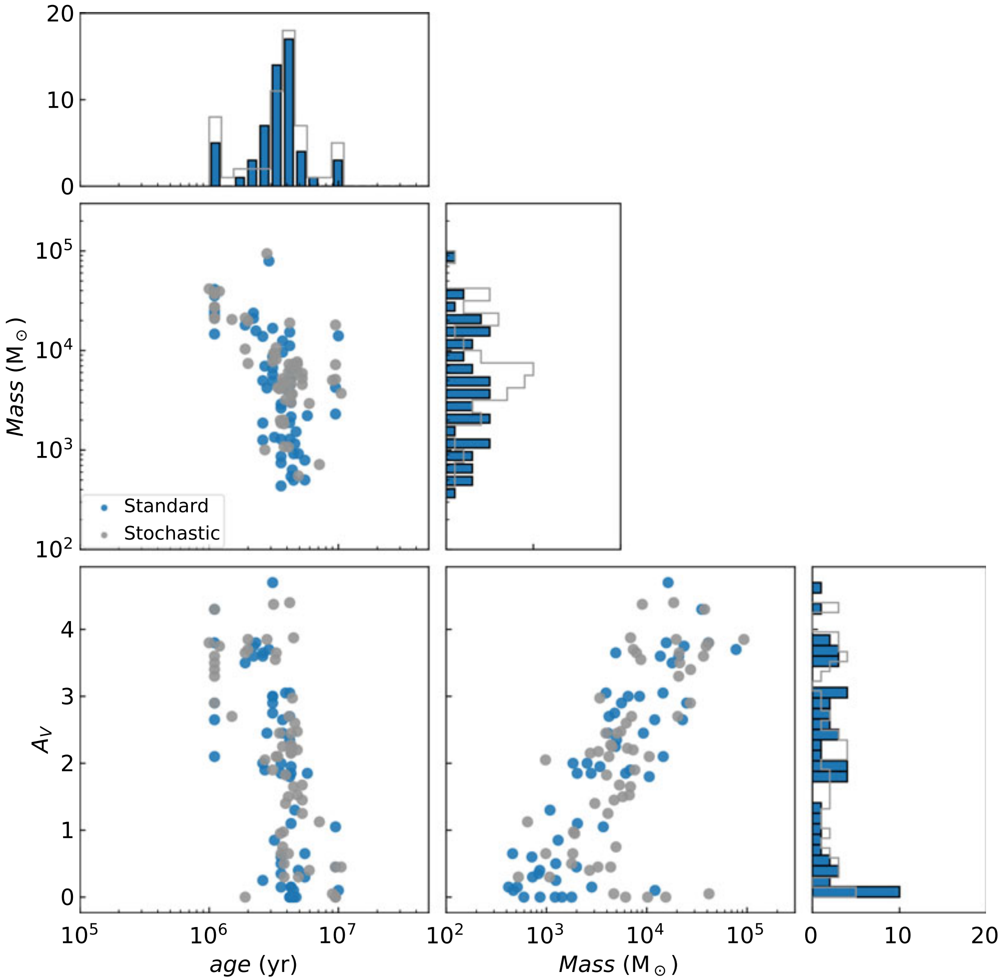

Figure 1. Distribution of derived *age*, *mass*, A_V for the clusters in NGC 1386 for both the *standard* (blue dots) and *stochastic*(gray dots) fitting. Histograms on each axis show the marginalized distributions of each parameter.

blues in Fig. 1). Even though physical parameters derived using *standard* or *stochastic* model can be different for individual clusters, the global conclusions are the same.

References

Bressan A., Marigo, P., Girardi, L., Salasnich, B., Dal Cero, C., Rubele, S., Nanni, A. 2012, *MNRAS*, 427, 127

Bruzual A. G., 2002, in Geisler D. P., Grebel E. K., Minniti D., eds, Vol. 207, Extragalactic Star Clusters. p. 616 (arXiv:astro-ph/0110245)

Charlot S., Bruzual G. 2022, *In preparation*

Chabrier G., 2003, *PASP*, 115, 763

Magris C., G, Mateu P., J., Mateu, C., Bruzual A., G., Cabrera-Ziri, I., Mejía-Narváez, A.. 2015,. *PASP*, 127, 16

Turner, J.A. *et al.* 2021, *MNRAS*, 502, 1366

Prieto, M.A., Fernandez-Ontiveros, J.A., Bruzual, G., Burkert, A., Schartmann, M., Charlot, S., 2019, *MNRAS*, 485, 3264

Prieto, M.A. et al 2022, *In preparation*

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