MODERN ASTRONOMY: FROM THE EARLY UNIVERSE TO EXOPLANETS AND BLACK HOLES
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Peculiar structure of isolated dwarf galaxy ESO 149–003

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Abstract. The modern deep sky DESI Legacy Surveys allow us to study of extremely low surface brightness structures. Visual inspection of Local Volume galaxies reveals that the dwarf galaxy ESO 149–003 contains shell-like structures that are characteristic of giant elliptical galaxies. This isolated dwarf galaxy, located at a distance of 7 Mpc in the direction of Antivirgo, appears to have absorbed its neighbour. In this paper we analyse the stellar population and star formation history of this galaxy. We estimate the frequency of similar systems by visual inspection of the Local Volume galaxies using images from the Legacy Survey.

Keywords: galaxies: individual (ESO 149–003), star formation, stellar content, structure

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1 Introduction

The Local Volume, because of its proximity, provides a unique opportunity to study a population of dwarf galaxies that is lost at larger distances. ESO 149–003 caught our attention because of its unusual structure, characteristic of shells around giant elliptical galaxies due to head-on collisions with neighbours and tidal interactions. Its images from the Legacy Survey and the Hubble Space Telescope (HST) are shown in Fig. 1. ESO 149–003 is a highly isolated galaxy at a distance of 7 Mpc in the direction of Antivirgo. The nearest giant galaxy, NGC 253, is 3.7 Mpc away. Radio observations revealed perturbations in the kinematics of the gas, but the authors did not find any peculiar structures in optical images of the galaxy (Józsa et al. 2021). ESO 149–003 has been observed with the Hubble Space Telescope (HST), allowing us to analyze its stellar population in detail.

2 Analysis

The image of the galaxy ESO 149–003 was obtained as part of the HST 12546 program (PI: R. B. Tully). The galaxy was observed in the $F606W$ and $F814W$ filters for 15 minutes each. Stellar photometry was performed using the Dolphot package (Dolphin 2000, 2016). The photometric limit is about $F814W \approx 27$ mag. For further analysis, we divided the color-magnitude diagram (CMD) into 4 regions according to different stellar populations (see the left panel of Fig. 2). Blue dots correspond to the main sequence branch, purple dots to the red supergiant branch, red dots to the red giant branch, and green dots to the asymptotic branch. This

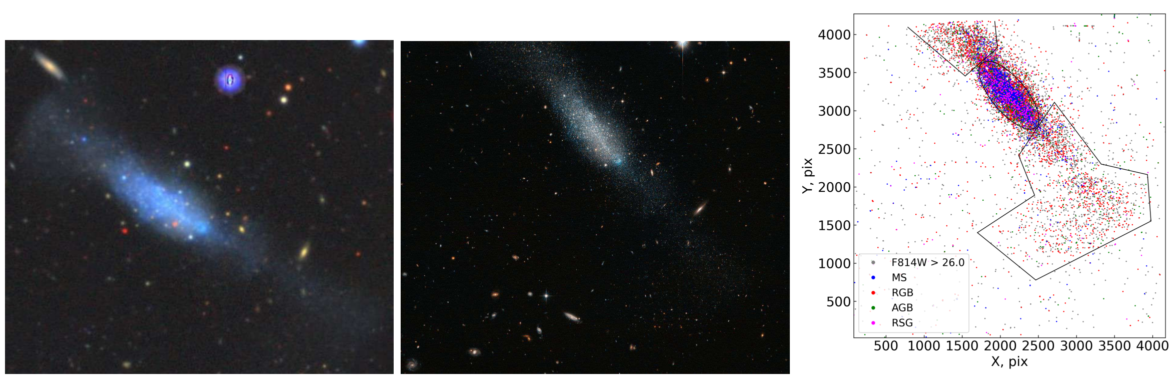

Fig. 1. The galaxy in frames from the Legacy Survey, an image from the Hubble telescope, and a map of the distribution of stars around the galaxy.

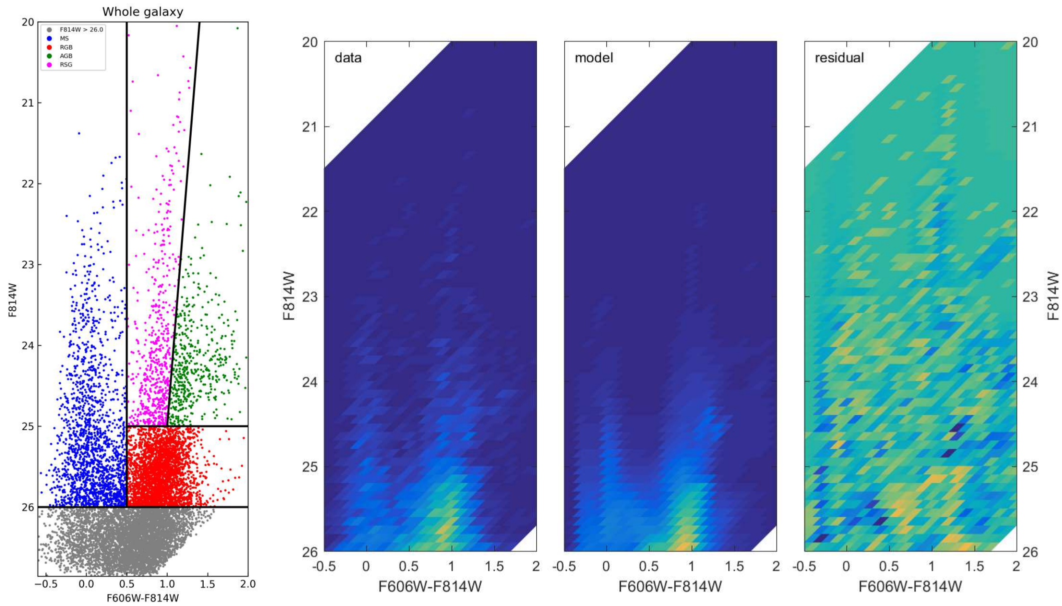

Fig. 2. CMD diagram of stars in the whole galaxy and star formation history diagram.

highlights stellar populations of different ages, from the youngest main sequence stars (age $\lesssim$ 300 Myr) to the oldest stars red giant stars (age $\gtrsim$ 1–2 Gyr). The distribution map of stars in the galaxy is shown in the right panel of Fig. 1. It allows us to check the variation of the stellar populations in different regions of the galaxy. There is a statistically significant difference in stellar populations between the main body and the "skirt"-like structures. The main sequence to red giant ratio in the main body is MS/RGB $= 1.08 \pm 0.04$, while in the skirts the ratio is only MS/RGB $=$ 0.14–0.16 ± 0.02. This suggests that young stars are practically not involved in the formation of these skirt structures.

We reconstructed the star formation history using the StarProbe (Makarov & Makarova 2004) program. It fits the observed CMD by a linear combination of model Hess-diagrams based on the Padova2000 theoretical stellar evolution isochrones (Girardi et al. 2000). We have not constrained the metallicity of the stellar populations. We find that the total stellar mass of ESO 149–003 is $\sim 8.2 \times 10^7\ M_{\odot}$. During the initial burst of star formation, about 45% of the stellar mass was formed. The stellar mass increased by another 36% during the period from $\sim$ 13 to 1.7 Gyr. The most recent burst of star formation began about 230 Myr ago and formed 12% of all stars.

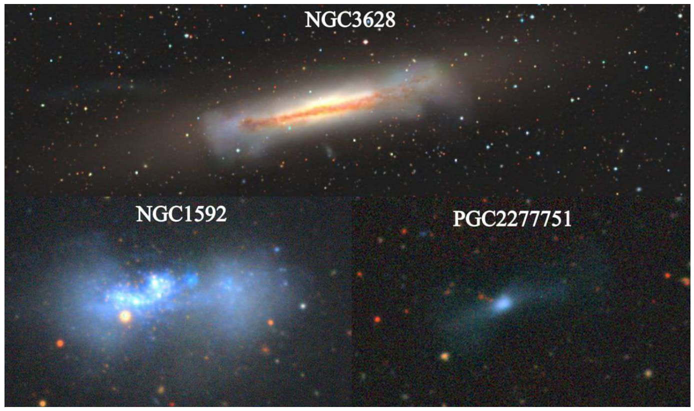

Fig. 3. Examples of galaxies with shells.

The modern star formation rate is $\sim 0.03\ M_{\odot}\,\mathrm{yr}^{-1}$. The observed Hess diagram, the reconstructed model, and the residuals are shown in Fig. 2.

3 Search for shells

To estimate the frequency of such shells among dwarf galaxies, we performed a visual inspection of all 992 Local Volume galaxies falling within the footprint of the DESI Legacy Surveys (Dey et al. 2019). As a result, we selected 201 out of 992 galaxies that show evidence for the presence of various peculiarities. Of these, 26 dwarf galaxies show the tidal structures similar to ESO 149–003 (see examples in Fig. 3).

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References

Dey A., Schlegel D.J., Lang D., et al., 2019, AJ, 157, id. 168
Dolphin A., 2016, Astrophysics Source Code Library, record ascl:1608.013
Dolphin A.E., 2000, PASP, 112, 776, p. 1383
Girardi L., Bressan A., Bertelli G., et al., 2000, A&AS, 141, p. 371
Józsa G.I.G., Thorat K., Kamphuis P., et al., 2021, MNRAS, 501, p. 2704
Makarov D.I. and Makarova L.N., 2004, Astrophysics, 47, 2, p. 229