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The spatial segregation impact on the star formation histories of nearby dwarf spheroidal galaxies

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Abstract. Using our HST/ACS observations of the recently found isolated dwarf spheroidal galaxies, we homogeneously measured their star formation histories (SFHs). We determined SF rate as a function of time, as well as age and metallicity of the stellar populations. All objects demonstrate complex SFH, with a significant portion of stars formed 10–13 Gyr ago. Nevertheless, stars of middle ages (1–8 Gyr) are presented. In order to understand how the SF parameters influence the evolution of dSphs, we also studied a sample of nearest dSphs in different environment: isolated ($d < 2$ Mpc); beyond the Local Group virial radius (but within the LG zero velocity sphere); and the satellites of M31 located within the virial zone (300 kpc). Using archival HST/ACS observations, we measured their SFHs. A comparative analysis of the parameters obtained give us a possibility to distinguish a possible effect of the spatial segregation on the dSphs evolution scenario.

Keywords. galaxies: dwarf, galaxies: stellar content, (galaxies:) Local Group, galaxies: evolution, galaxies: individual (KKR 25, KKs 03, KK 258, And XVIII, Tucana, Cas dSph, And XXVIII, And XXIX)

1. Introduction

Nearby dwarf galaxies are an excellent laboratory to study the processes of star formation, since they are resolved into individual stars, and their structure is relatively simple. At the same time, the role of dwarf galaxies in the formation and evolution of visible structures in the Universe is very significant. In recent years, we have discovered and investigated a number of isolated dwarf spheroidals (dSphs) (Makarov *et al.* 2012, Karachentsev *et al.* 2014, Karachentsev *et al.* 2015, Makarova *et al.* 2017). It is important to get detailed consideration to such the rare objects, since the common recent scenario of dSphs formation suggests that the dwarfs are formed due to the interaction between a rotationally supported dwarf irregular galaxy and a MW-sized host galaxy. Then rather isolated dwarfs should be exceptionally irregular. However, we have found a number of dwarf spheroidal galaxies located in isolation.

2. The selected sample

In addition to the studied isolated dSphs we have selected the dSph and dwarf transitional (dTr) galaxies in the Local Group observed with HST/ACS or WFPC2. Our sampling criteria meet the goal of obtaining a color–magnitude diagram, where some basic features (upper Red Giant Branch (RGB), Red Clump (RC), and probably Horizontal Branch (HB)) have similar photometric accuracy. Such criteria allow us to compare the measurements of the SFH, and to reveal the difference in evolution, without worrying

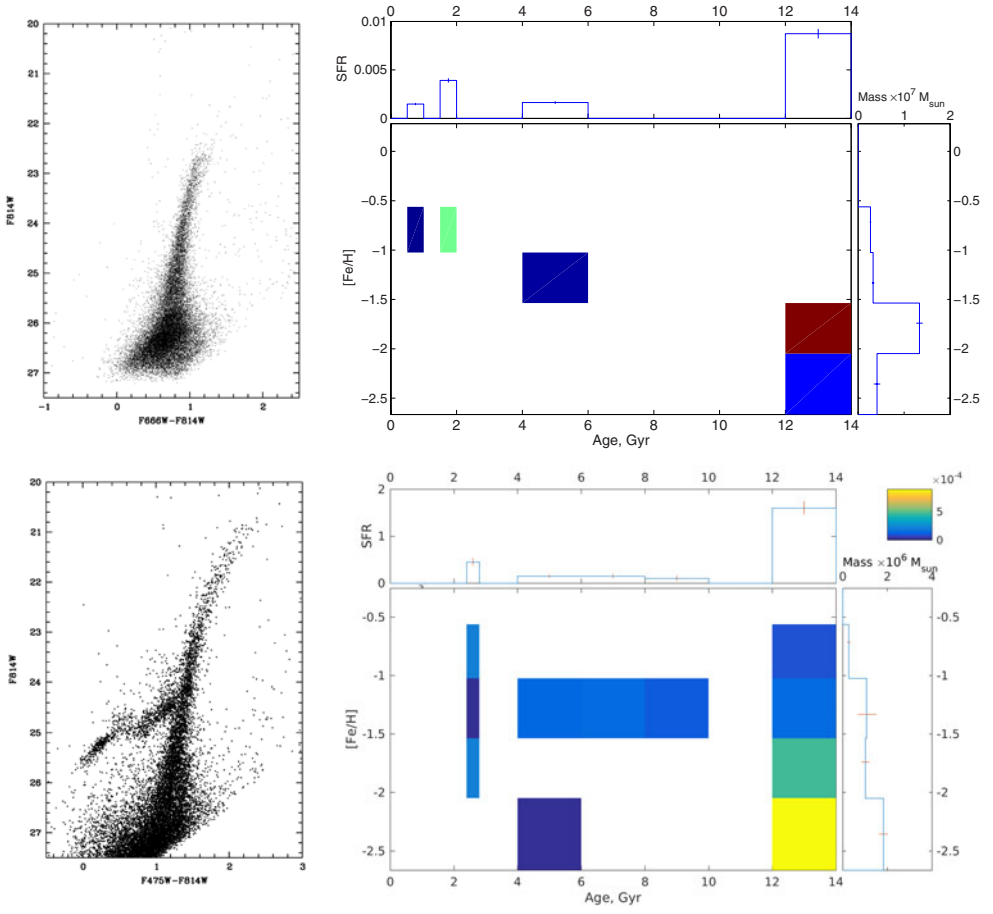

Figure 1. Left part: The color–magnitude diagram of the isolated dwarf KKs 03 (to the top), and the Tucana dSph CMD (to the bottom). **Right part:** The SFH for the two galaxies. In the both charts the top panel shows star formation rate (SFR) ($M_\odot$/yr) against an age of the stellar populations. The bottom panel represents the metallicity of stellar content as a function of age. The colored boxes represent periods of star formation for the given metallicity. The right panel is stellar mass vs. metallicity.

about the difference in the input data. Most of the galaxies that meet our criteria are located in the M 31 group. The selected objects sizes are preferably less than 3 arcmin to fit HST/ACS field of view. Finally, in this work we have considered 8 galaxies: KKR 25, KKs 03 and KK 258 are isolated dwarf spheroidals; And XVIII and Tucana are objects within the Local Group zero–velocity sphere; Cas dSph, And XXVIII and And XXIX are galaxies within (or nearly within) the Andromeda virial radius.

3. Stellar photometry and SFH

We derive quantitative star formation histories (SFH) of the galaxies using our StarProbe software (Makarov & Makarova 2004). Photometry of resolved stars in the galaxies was made with DOLPHOT stellar photometry software (Dolphin 2000). In the Fig. 1 the color-magnitude diagrams (left part) and the resulting SFHs (right part) are shown for the representative dwarfs of our sample: KKs 03 is isolated one, and Tucana is situated within the Andromeda virial radius.

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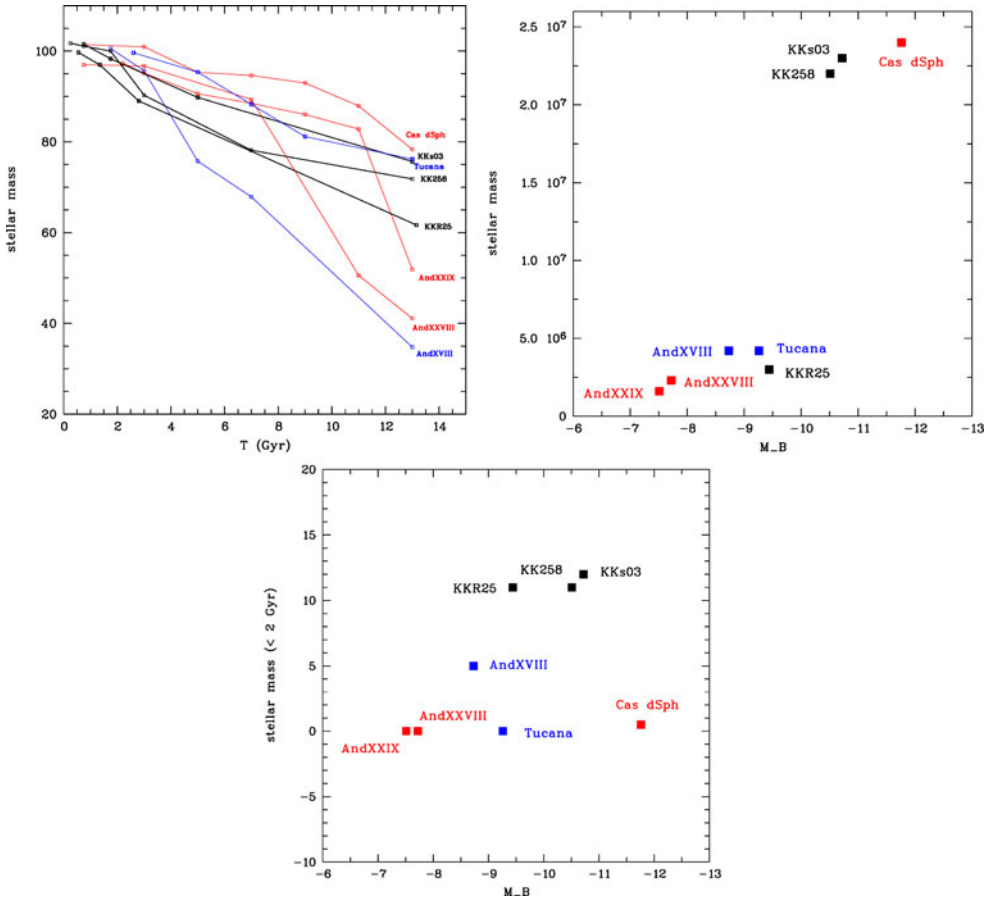

Figure 2. Left panel: Stellar mass growing with time, according to our SFH measurements for the 8 studied dwarfs. **Right panel:** Total stellar mass respective to the absolute stellar magnitudes for the studied DGs. **Bottom panel:** Mass of the stars formed in the last 2 Gyr respective to the absolute stellar magnitudes for the studied DGs.

4. The evolution of the dwarf galaxies

Fig. 2 (left panel) display the galaxy stellar mass growing with the time and the total stellar mass vs. absolute stellar magnitude (right panel). It is obvious, that the DGs with higher stellar mass form bulk of their stars early (Tucana is the interesting exception). At the bottom panel highly isolated objects show residual recent star formation clearly ($> 10\%$ of the total stellar mass), whereas the DGs within the virial radius are almost quenched. It is possible, that Tucana was also situated close to the gravitational center in the past. Perhaps this DG was quenched and lost some of their stellar mass during close encounters near the group's center, and then moved to its edge.

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