Dwarf Galaxies: From the Deep Universe to the Present
Proceedings IAU Symposium No. 344, 2019
K. B. W. McQuinn & S. Stierwalt, eds.

doi:10.1017/S1743921318005550

Population gradients in dwarf spheroidal galaxies KKs 3 and ESO 269-66

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Abstract. We compare the properties of stellar populations for globular clusters (GCs) and field stars in two dwarf spheroidal galaxies (dSphs): ESO269-66, a close neighbour of NGC5128, and KKs3, one of the few isolated dSphs within 10 Mpc. We analyse the surface density profiles of low and high metallicity (blue and red) stars in two galaxies using the Sersic law. We argue that 1) the density profiles of red stars are steeper than those of blue stars, which evidences in favour of the metallicity and age gradients in dSphs; 2) globular clusters in KKs3 and ESO 269-66 contain 4 and 40 percent of all stars with [Fe/H] ~ 1.6 dex and the age of 12 Gyr, correspondingly. Therefore, GCs are relics of the first powerful star-forming bursts in the central regions of the galaxies. KKs 3 has lost a smaller percentage of old low-metallicity stars than ESO269-66, probably, thanks to its isolation.

Keywords. galaxies: dwarf - galaxies: star clusters - galaxies: individual: KKs 3, ESO 269-66

1. What do we learn from star formation histories of two dSphs?

It has long been known that stellar population gradients exist in the early-type dwarf satellites of our Galaxy and M31 (e.g. Harbeck *et al.* 2001, Davidge 2005, McConnachie 2012). The dispersion of colours of red giant branch (RGB) stars is large in many dSphs (Karachentsev *et al.* 2007, Sharina *et al.* 2008). Colours of stars exhibit the well-known age-metallicity degeneracy (e.g. Dolphin *et al.* 2003). However, in the statistical sense, blue RGB stars have systematically older ages and lower metallicities than the red ones.

ESO 269-66 is brighter ($M_V=-14.4$ mag), larger (Rad=1.2 kpc) and more distant ($D = 3.82$ Mpc) (Karachentsev *et al.* 2013) than KKs 3 ($M_V=-12.3$, Rad=0.75 kpc and D=2.12 Mpc) (Karachentsev *et al.* 2015, Karachentsev *et al.* 2015). The mean colour of RGB at $M_I=-3.5 \pm 0.1$ mag and the corresponding dispersion of stellar colours in KKs 3 $\sigma(V-I)$=0.08 mag are lower than in ESO 269-66 $\sigma(V-I)$=0.19 mag (Sharina *et al.* 2017, Sharina *et al.* 2008). At the same time, star formation histories (SFHs) of KKs 3 (Karachentsev *et al.* 2015) and of ESO 269-66 (Makarova *et al.* 2007, Crnojevic *et al.* 2011) look similar. The galaxies have experienced three main star forming episodes: 1) most powerful bursts of star formation (SFBs) 12-14 Gyr ago, 2) several less intensive SFBs 2-6 Gyr ago, 3) last SFBs ~1 Gyr ago leading to the final exhaustion of gas.

Brightest representatives of stellar populations in these faint galaxies are GCs. The nuclear GC in KKs 3 is fainter ($M_V = -8.5$ mag) than the one in ESO 269-66 ($M_V = -14.4$ mag). The ages and metallicities of two nuclei are similar (Sharina *et al.* 2017). Approximately, 57% of stars in KKs 3 and 27% of stars in ESO 269-66 have [Fe/H] ~ -1.6 dex according to the SFHs. The masses of the nuclear GCs in KKs 3 and ESO 269-66 are 6.3E+5$M_\odot$ and 2.3E+ 6$M_\odot$ if we adopt $(M/L)_V$=3 in solar units (Djorgovski 1993). Therefore, the GCs in KKs 3 and ESO 269-66 contain 4 and 40%, correspondingly, of old ($T \sim 12 \div 14$ Gyr) and low-metallicity ([Fe/H]~ -1.6) stars in the galaxies. Thus,

Table 1. Parameters of the Sersic law for the surface density profiles of red and blue stars in two dSphs: central surface density [stars/arcmin^2], effective radius [arcmin] and shape parameter.

KKs3	$lg(SD_{centr})$	r_{eff}	n	**ESO 269-66**	$lg(SD_{centr})$	r_{eff}	n
blue stars	3.1 ± 0.1	4.8:	1.4:	blue stars	3.3 ± 0.03	3.2 ± 0.5	1.2 ± 0.1
red stars	3.1 ± 0.04	3.5 ± 1.1	1.4 ± 0.2	red stars	3.7 ± 0.03	1.7 ± 0.1	1.0 ± 0.05

one may suppose that the isolated KKs 3 has lost 10 times less RGB stars during its evolution, than ESO 269-66 situating in the centre of the Cent A group of galaxies.

2. Stellar density profiles for red and blue stars in two dSphs

The way how blue and red stars are selected in the galaxies is the following. We select bright stars with low photometric errors and the detection completeness 100%, i.e. $M_I < -3$ mag in ESO 269-66 and $M_I < -2$ mag in KKs 3. The RGB part of the isochrone from Bertelli *et al.* (2008) with Z=0.0004, T=1 Gyr and Y=0.26 approximately separates RGB stars in the galaxies into the blue and red samples.

We divide the two-dimensional spatial distribution of the stellar objects in our photometry into a grid with a pixel width of 0.5 arcsec and associate with each pixel the number of stars it contains. We then derive the azimuthally-averaged profiles of the resulting stellar distributions and describe the shapes of the profiles using the Sersic function (Sersic 1968, Ciotti & Bertin 1999). The corresponding model parameters listed in Table 1 indicate that the effective radii of the distributions in two galaxies for the blue stars are larger than for the red ones. The occurrence of population gradients in dSphs situating in different environments indicates that the internal evolution of these faint galaxies largely controls their properties of stellar populations and structure.

Acknowledgements

This work is supported by the grant RSF 14-12-00965.

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