GRADIENTS OF METALLICITY AND AGE OF STARS IN THE DWARF SPHEROIDAL GALAXIES KKs 3 AND ESO 269-66

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1. Introduction

1.Dwarf spheroidal galaxies (dSphs) and dwarf elliptical galaxies (dEs) do not contain stars younger than 1 billion years. Unlike irregular dwarf galaxies with low surface brightness, globular galaxies cannot be detected in neutral hydrogen (HI) lines and do not contain active star-forming regions.

2.Observations have found a gradient in the stellar population properties of dwarf spheroidal galaxies in the Local Group and dwarf elliptical satellite galaxies of M31, with higher metal abundances and younger ages in the central regions.

1. Introduction

Table 1: Observed Properties of KKs 3 and ESO 269-66.

	KKs 3	Ref.	ESO 269-66	Ref.
RA(J200.0)	$2^h24^m44^s4$	[4]	$13^h13^m09^s1$	[25]
Dec.(J200.0)	$-73^o30''51'$	[4]	$-44^o53''24'$	[25]
E(B − V)	0.045	[4]	0.093	[25]
Distance, Mpc	2.12	[4]	3.82	[25]
Diameter, kpc	1.5	[4]	2.4	[25]
(V − I), mag	0.77	[24]	1.06	[23]
M_V	-12.3	[24]	-14.4	[25]
M_{HI} , $M_\odot$	$1.1{\cdot}10^5$	[24]	$< 0.9 \cdot 10^5$	[25]
$[Fe/H]_{12\div14Gyr}$,dex	-1.9	[4]	-1.75	[20]

2. Star-formation bursts in KKs 3 and ESO 269-66 and the formation of globular clusters

$[Fe/H]$	T	SFR	M_{stars}
		KKs 3	
-2.36	[12 - 14]	[0.34e-03÷4.47e-03]	4.12e+06
-1.74	[12 - 14]	[0.35e-03÷1.37e-02]	1.33e+07
-1.33	[4 - 6]	[0.14e-03÷3.39e-03]	3.25e+06
-0.72	[0.5 - 1]	[0.11e-03÷2.83e-03]	7.37e+05
-0.72	[1.5 - 2]	[0.21e-03÷8.05e-03]	1.96e+06
		ESO 269-66	
-1.74	[12 - 14]	[2.55e-03÷10.35e-03]	6.50e+06
-1.33	[12 - 14]	[3.00e-03÷2.08e-01]	1.74e+08
-0.72	[1.5 - 2]	[7.88e-04÷4.43e-03]	8.65e+05
-0.72	[2 - 4]	[6.90e-04÷9.79e-03]	9.07e+06
-0.72	[4 - 6]	[1.24e-03÷9.45e-03]	8.17e+06
-0.41	[1.5 - 2]	[2.70e-03÷1.12e-01]	2.73e+07
0.18	[0 - 0.5]	[1.30e-03÷6.70e-02]	1.64e+07

Table 2: Details of the Star-Formation Histories of KKs 3 [4] and ESO 269-66 [20].

2. Star-formation bursts in KKs 3 and ESO 269-66 and the formation of globular clusters

1.Currently, no young star-forming regions have been observed in these two galaxies.

2.Based on models of stellar formation history, the average metal abundance and metal abundance range of stars of different ages in KKS 3 and ESO 269-66 are proportional to the mass of the galaxy.

3.The ages and metallicities of the central globular clusters in KKs 3 and ESO 269-66 correspond to the earliest periods of star formation in these galaxies.

2. Star-formation bursts in KKs 3 and ESO 269-66 and the formation of globular clusters

4.The average stellar metallicity of ESO 269-66 is higher and the metallicity range is larger.

5.They used data from Table 2 to calculate the proportion of stars with a metallicity of [Fe/H] ~−1.6 dex in the globular clusters. They found that approximately 57% of stars in KKs 3 and 27% in ESO 269-66 exhibited this level of metallicity.

6.They found that for stars with ages ranging between 12-14 billion years and [Fe/H] ~−1.6 dex, the globular clusters contained roughly 4% and 40% of all stars in KKs 3 and ESO 269-66, respectively.

3. The distributions of red and blue galaxies in KKs 3 and ESO 269-66

1.Stars within ~47 pc radii of globular clusters in KKs 3 and ESO 269-66 have bluer colors than average stars in these galaxies, indicating lower metallicities.

2.Despite different distances and red giant branches (RGB) width variations, the situation is similar in both galaxies.

3.Only RGB and asymptotic giant branches (AGB) stars are visible in the HST images of KKs 3 and ESO 269-66.

3. The distributions of red and blue galaxies in KKs 3 and ESO 269-66

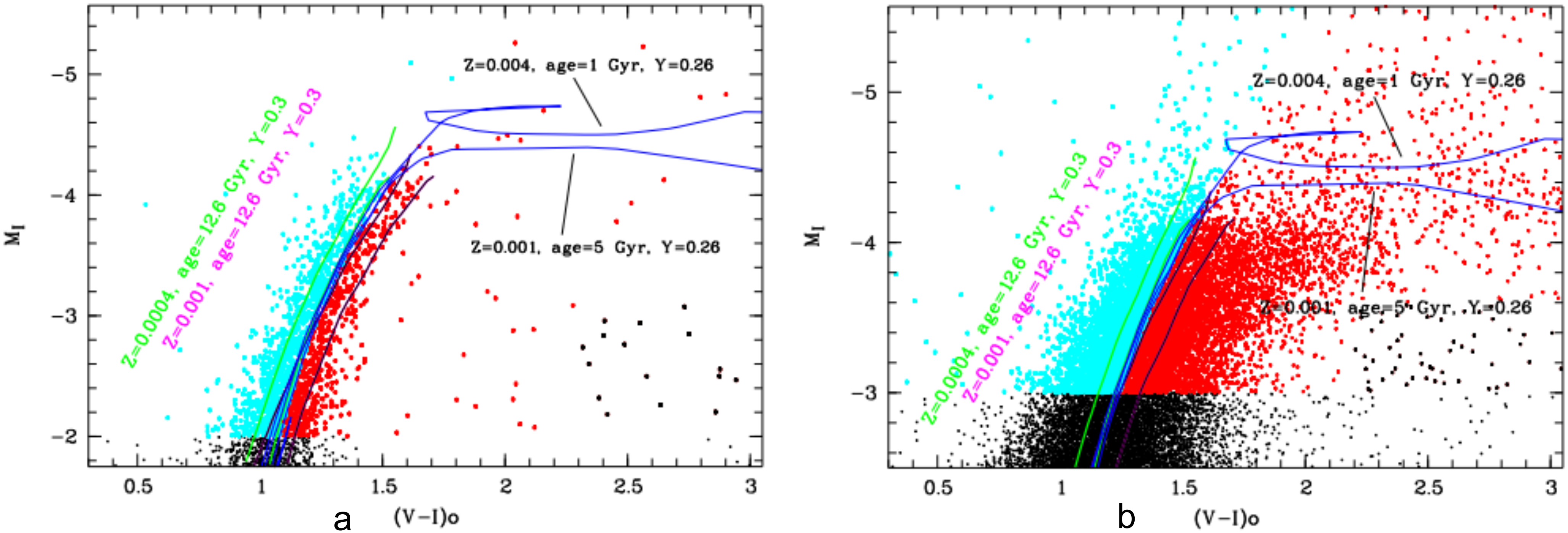

Figure 1: ”Color-magnitude diagrams” for KKs 3 (a) and ESO 269-66 (b). The blue stars (blue points) and red stars (red points) were selected as shown in the figures.

Among the 36,763 stars in ESO 269-66 analyzed, 5,753 red stars and 3,389 blue stars were selected. The CMD of KKS 3 contains 22,707 stars, of which 632 red stars and 1,032 blue stars were selected using the method shown in Figure 1.

4. Density profiles of the stars

1.They used stellar photometry data to build stellar density profiles for KKs 3 and ESO 269-66.

2.They isolated blue and red stars with small photometric errors and nearly 100% detection coverage from the entire dataset.

3.The two-dimensional distribution of stars on the galaxy's surface was divided into 0.5 arcsec cells, and the number of stars in each cell was counted.

4.After background subtraction, these counts formed the basis for constructing the stellar density profiles of KKs 3 and ESO 269-66.

4. Density profiles of the stars

For modelling the shapes of the density profiles as a function of the radius r of the galaxies, they have used the Sersic function :

$$I(r) = I_0 \cdot e^{-\nu_n \left(\frac{r}{re}\right)^{1/n}}$$

where I0 is the central intensity, re is the effective radius, n is a positive real number representing the degree of curvature of the profile, and vn is a constant chosen so that half the total luminosity is radiated within the effective radius with:

$$\nu_n \sim 2n - 1/3 + 4/(405n) + 46/(25515n^2)$$

4. Density profiles of the stars

Table 3: Parameters of the Sersic Model [28,29]

Object	$lg(SD_{centr})$ [stars/arcmin^2]	r_{eff} [arcmin]	n
KKs3			
Blue stars	3.12 ± 0.08	4.82:	1.38:
Red stars	3.10 ± 0.04	3.49 ± 1.13	1.41 ± 0.16
ESO 269-66			
Blue stars	3.34 ± 0.03	3.24 ± 0.46	1.18 ± 0.08
Red stars	3.74 ± 0.03	1.71 ± 0.10	1.00 ± 0.05

In units of surface brightness, this will be ：

$$\mu(r) = \mu_0 + \frac{2.5\nu_n}{ln10}(\frac{r}{r_e})^{1/n}$$

where μ0 is the central surface brightness, SDcentr is the central surface brightness, reff is the effective radius, and n is the shape factor for the profile.

4. Density profiles of the stars

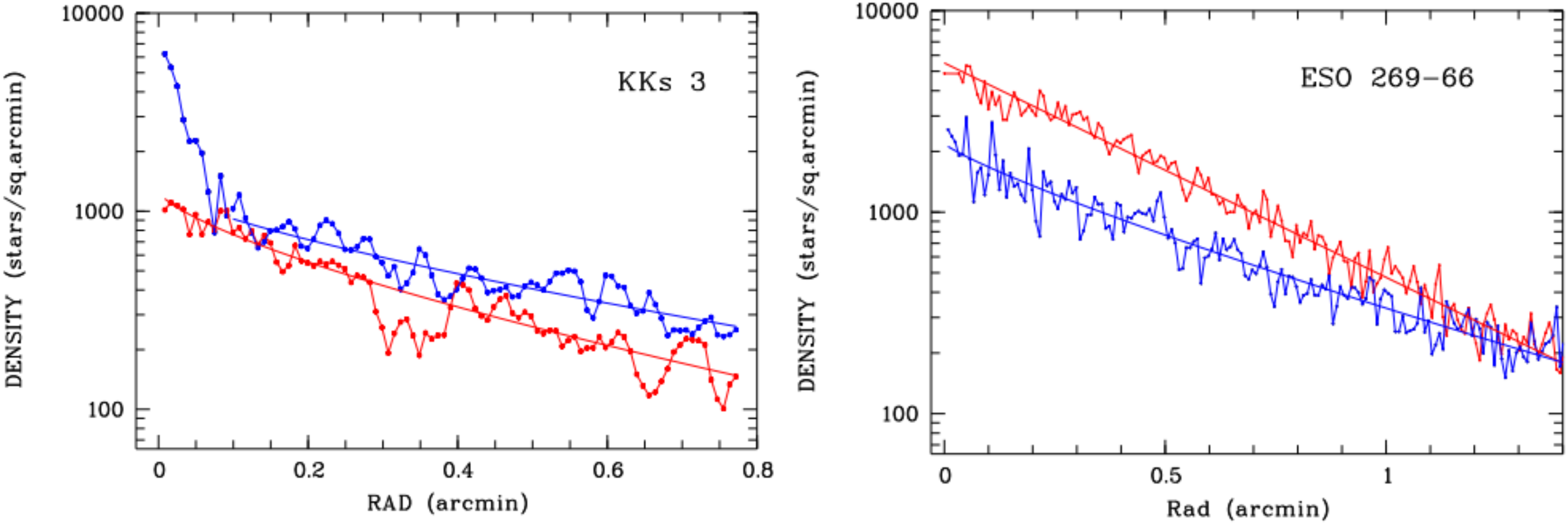

Figure 2: Surface density profiles for blue (dark grey) and red (light grey) stars in KKs 3 (a) and ESO 269-66(b) with superimposed Sersic model curves. The contribution of the galactic background (1 star/sq.arcmin)has been subtracted from each point in the profiles.

5. Conclusion

1.A recent study investigated the distribution of blue and red stars in KKs 3 and ESO 269-66, revealing stellar population gradients in both galaxies. The older, low-metallicity blue stars exhibited flatter density profiles compared to the younger, higher-metallicity red stars, dominating the outer regions similar to massive spiral galaxies.

2.The centers of KKs 3 and ESO 269-66 harbor residuals of powerful star formation outbursts, manifesting as globular clusters. These clusters contain a significant percentage of the total stars in each galaxy—4% in KKs 3 and 40% in ESO 269-66—with metallicities ranging from [Fe/H] ~ −1.5 to −1.6 dex and ages of 12-14 Gyr.