DECOMPOSITION OF THE PROFILES OF 20 GALAXIES

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Abstract.
Decomposition technique in the spirit of Kormendy (1977), but where both bulge and disk profiles are modeled using Sersic's (1968) formula, is applied on 20 published galactic disks profiles. The result of Andredakis et al (1995) that the radial bulge profiles of the early type galaxies are close to the de Vaucouleurs (1948), but the bulges of the later galaxies have more compact shapes, is confirmed. We also confirm our previous results that the radial disk profile shapes of the later galaxies are close to the Freeman's (1970) model and only slight convex, in contrast to those of the early galaxies which shapes are obvious convex. The most deep profiles shows that the minimal observation depth sufficient enough to study the true shape of the radial disk profile in B,V, R, I, J, H and K band should be about 27.5, 26.5, 26,25.5,25,24.5 and 24 mag/arcsec^2, respectively.
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In the last decades much work has been done in order to improve the methods for ascertaining the main components (bulge and disk) of the disk galaxies based on their optical photometric profiles. The papers of Freeman (1970), Kormendy (1977), Boroson (1981),Shombert & Bothum (1987), Kent (1987), Capaccioli et al (1987), Andredakis & Sanders (1994), de Jong (1986), Moriondo et al (1997), Anderson et al (2004) etc. leads to a gradual progress in resolving this difficult topic. In all these studies, except the works of Kormendy (1977) and Anderson et al. (2004) the disk shape is modeled as exponential, following Freeman (1970).

In our previous papers (Georgiev 2004a, Georgiev & Stanchev 2004, Georgiev et al. 2004 and Georgiev 2004b) we introduced modeling of the smooth convex profiles of the galactic disks by means of the Sersic's (1968) formula. The decomposition in the spirit of Kormendy (1977) was made using the Sersic's (1968) formula for both the bulge and the disk shapes in order to find the optimal exponential numbers (see Georgiev 2004b). Here we give the results after applying of this approach for 20 galaxies profiles, taken mainly from classical papers.

The data about of the galaxy profiles are summarized in Table 1 where the first 8 profiles are taken from our previous studies. The column content is as follows: 1 – the name of the galaxy, 2 – the morphological type code (LEDA), 3 – axial ratio (LEDA), 4 – photometry band of the profile, 5 – limiting surface magnitude of the profile, 6 – exponential number of the bulge (see (1) in Georgiev 2004b), 7 – optimal exponential number of the disk (see (1) in Georgiev 2004b), 8 – predicted central surface magnitude of the disk, 9 – logarithmic disk-to-bulge scale length ratio, 10 – difference between the computed total magnitudes of the bulge and the disk and 11 – references for the profiles and decomposition parameters.

Table 1. Basic data about the galaxies' profiles

Name	Type	a/b	Band	Lim	N_b	N_d	μ_{d0}	$\log(H_d/H_b)$	M_b-M_d	References
1	2	3	4	5	6	7	8	9	10	11
MW	4.0	-	-	-	0.48	2.09	-	1.94	6.07	1,18
LMC	9.0	2.2	B	25.8	0.64	1.03	21.92	0.95	2.35	2,18
SMC	9.0	1.1	B	25.3	1.09	1.25	21.64	1.09	3.90	2,18
M31	3.0	3.0	B	26.8	0.32	1.75	22.11	3.26	5.89	3,18
M33	5.8	1.7	B	25.8	0.50	1.41	21.83	1.58	4.51	4,18
M51a	4.2	1.4	B	25.6	0.74	2.87	21.18	1.44	2.79	5,19
M74	5.2	1.1	B	28.9	1.17	1.22	22.05	0.98	2.54	6,19
M83	5.1	1.1	B	23.8	0.50	1.90	20.12	1.90	4.84	1,18
N300	6.9	1.4	B	27.0	0.40	1.57	22.36	1.74	5.09	7,20
N1313	6.9	1.3	B	27.1	1.20	1.14	21.73	0.50	1.96	8,20
N1566	4.1	1.4	B	26.5	0.44	2.24	22.33	2.35	4.73	9,20
N6744	3.8	1.9	B	26.9	0.86	0.95	21.36	1.25	3.37	10,20
N7793	7.4	1.6	B	26.6	0.83	2.72	21.90	1.12	3.32	11,20
M51b	5.3	1.2	B	25.6	0.27	1.63	21.43	3.72	7.81	5,20
M101	5.9	1.0	B	24.1	0.34	1.35	21.84	2.83	6.92	5,20

N2403	6.0	2.0	B	25.0	0.67	1.28	20.89	1.18	4.07	12,20
M74	5.2	1.1	R	28.1	0.31	1.23	21.20	3.53	7.20	6,20
N5434	4.9	1.0	R	29.4	0.89	1.43	20.69	1.24	3.98	13,20
N5923	3.9	1.1	R	29.6	0.38	2.00	21.50	2.71	5.27	13,20
U9837	5.1	1.0	R	28.8	0.60	1.82	21.84	1.58	3.17	13,20
N4459	-1.5	1.3	B	26.2	1.91	1.00	21.43	0.26	0.13	1,20
N7457	-2.9	1.7	B	25.8	0.31	1.34	21.60	2.75	5.34	14,20
1Zw21	-	1.0	B	25.5	0.50	2.31	23.63	2.16	2.55	14,20
7Zw303	-2.0	1.0	B	25.2	0.75	2.20	22.59	1.43	1.35	14,20
N4216	2.8	4.5	B	25.3	1.58	6.46	22.46	0.64	-0.47	15,20
N4945	6.1	4.7	B	26.8	2.48	3.57	23.12	0.41	-0.45	16,20
U5389	6.0	10	R	26.0	1.54	4.31	22.19	0.58	-0.18	17,20
U9568	3.1	7.2	R	26.0	1.63	2.76	21.04	0.85	0.02	17,20

Sources: 1 - Freeman (1970), 2- de Vaucouleurs (1960), 3- de Vaucouleurs (1958), 4 – de Vaucouleurs (1959), 5 Okamura et al (1976), 6 - Natali et al (1992), 7 - de Vaucouleurs & Page (1962), 8 - de Vaucouleurs (1963a), 9 - de Vaucouleurs (1973), 10 - de Vaucouleurs (1963b), 11 - de Vaucouleurs (1980), 13 – Pohlen et al (2002), 14 – Kormendy (1977), 15 – Hamabe & Okamura (1982), 16 – de Vaucouleurs (1964), 17 – Karachentsev et al. (1992), 18- Georgiev (2004a), 19 – Georgiev (2004b), 20 – this work

The decompositions of all 20 profiles, published mainly in classical papers are illustrated in Fig.1 – 5. The disk shape is not convex only in the case of NGC 4459, NGC 6744, and in the case of NGC 7793 it is strongly truncated. In the most cases the 1^{st} and 2^{nd} order of the Sersic formula give almost identical results for the disk. Figure. 5 unifies edge-on galaxies that show evidences of ring-like disks. They are recognized after applying the second order Sersic formula for the disk shape (dashed line, see also the previous papers).

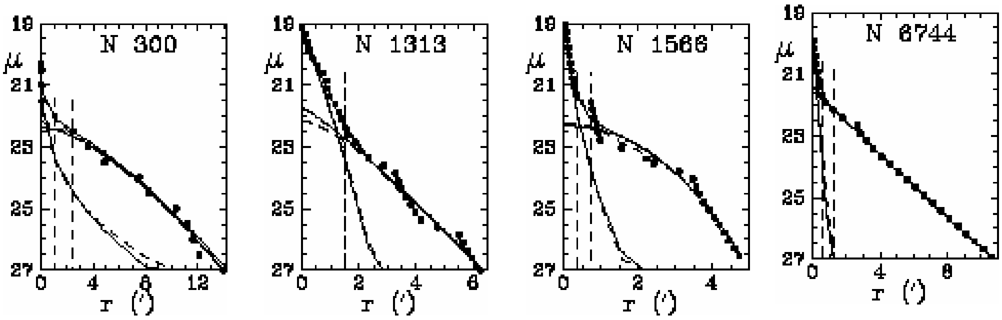

Fig.1: Profile decomposition of large galaxies in B-band, published by de Vaucouleurs. The solid curves represent the optimal model for the bulge, the disk and the restored profile based on the 1st order Sersic's formula for the disk modeling. The dashed curves represent the results when the disk is modeled by 2nd order Sersic's formula. The vertical dashed lines show the last point of the bulge region and the first point of the disk region of the profile, used as limiting points in the decomposition.

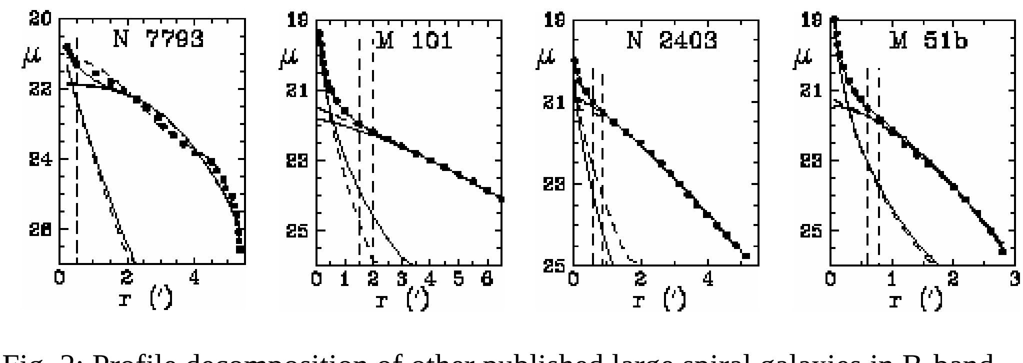

Fig. 2: Profile decomposition of other published large spiral galaxies in B-band. (see also Fig. 1).

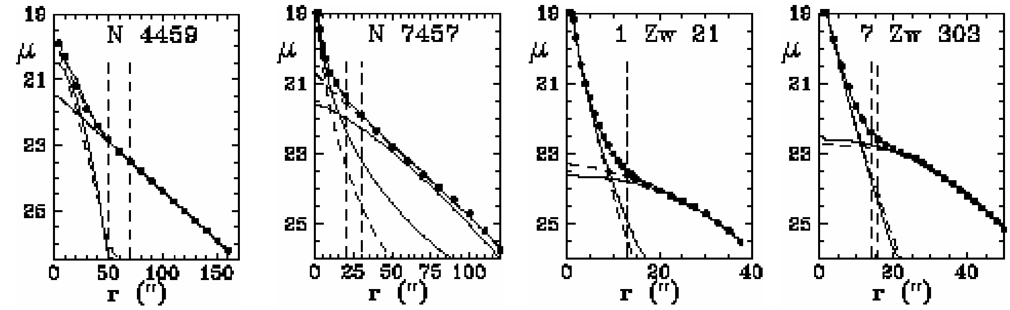

Fig. 3: Decomposition of published profiles of S0 galaxies in B-band (see Fig. 1).

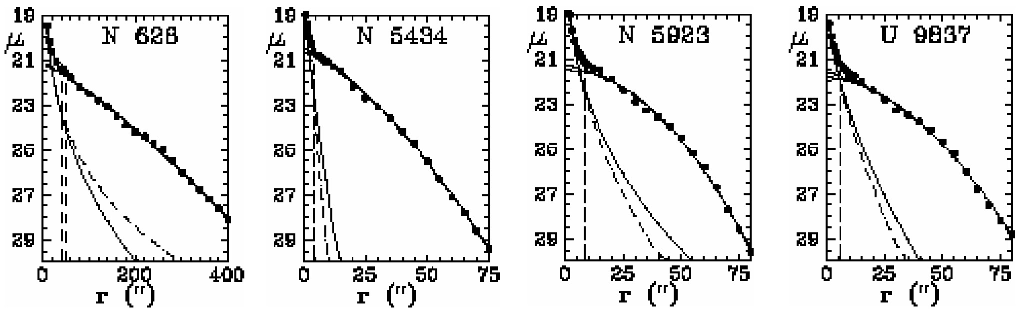

Fig. 4: Decomposition of deep profiles of Sb–Sc galaxies in R-band (see Fig.1).

We had used the deepest observations of face-on galaxy profiles, shown in Fig.3, to study the influence of the depth of the profile on the shape parameters, retrieved by our techniques. The results are given in Fig.6, where the deep face-on profiles of Natali et al (1992) and Pohlen et al. (2002) shows that the minimal deepness of the observations in order to study the true shape of the radial disk profile must be about 26 mag/arcsec^2 in R-band. Assuming the typical disk colour indexes the minimal deept must be about 24, 25, 25.5, 26.5 and 27.5 in K, J, I, V and B-band, respectively.

The correlation between the morphological type of the galaxy and the bulge/disk parameters is shown in Figure 7. Note, that the S0 galaxies from Fig. 4 and the edge-on galaxies from Fig. 5 are not used. The most left plot in

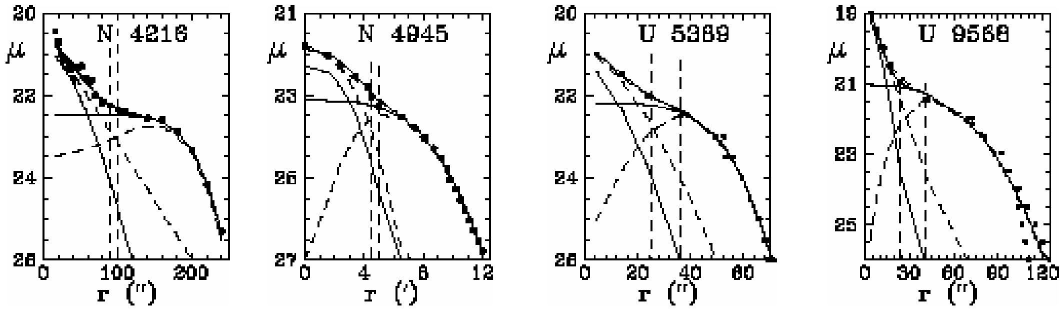

Fig.5: Decomposition of B-band profiles of edge-on galaxies with possible ring-like disks (see Fig. 1).

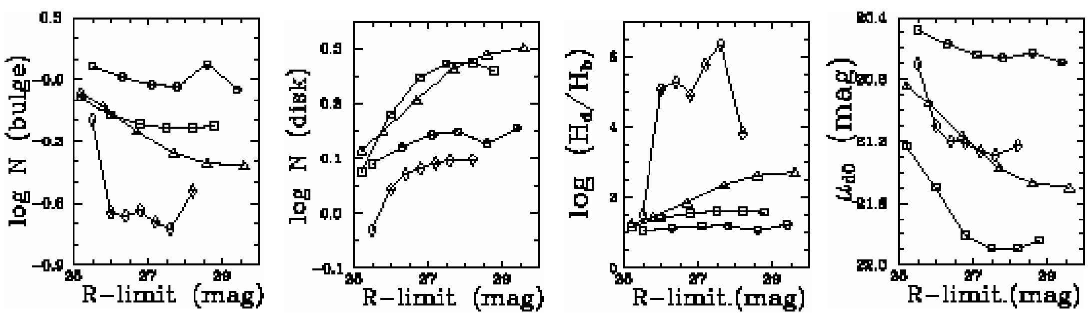

Fig.6. The correlation of the profile parameters according to artificially limited profile magnitude in the case of the galaxies M 74 (NGC 628, diamonds), NGC 5434 (circles), NGC 5923 (triangles) and UGC 9837 (squares).

Fig. 7 confirms the results of Andredakis et al. (1995), that the early type galaxies have bulge profiles close to the de Vaucouleurs (1948) "1/4 law" but the late type galaxies have more compact bulges. The middle plot of the left confirms our result – the disk profiles of the early type spiral galaxies are convex and that of the late type galaxies are flat, close to the Freeman's (1970) law (Georgiev 2004a, Georgiev et al. 2004). The other plots in Fig. 7 demonstrate how the disk-to-bulge scale length ratio and the difference between the computed total magnitudes of the bulge and the disk correlate with the morphological type,.

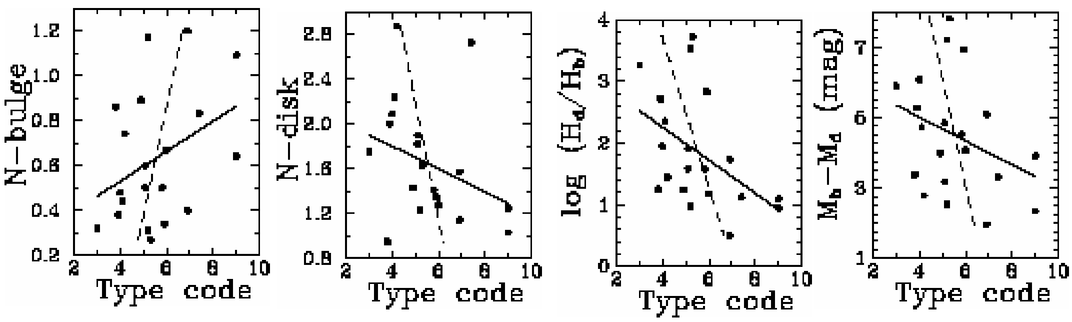

Fig.7. Correlation between the morphological type code and the bulge and disk exponential numbers, scale length ratio and difference between the magnitudes

Thus, in the case of 20 galaxies the disk profile shapes are modeled adequately through the Sersic's formula. This approach allows to recognize the disks of early type galaxies through their convex shapes, as well as to suspect for ring-like disks. It is a theoretical problem the shapes and the peculiarities of the disks to be explained.

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