1986RMxAA..12..101D

Rev. Mexicana Astron. Astrof. **12**, 101-108 (1986)

STRUCTURE OF SO'S IN CLUSTERS

R.R. de Carvalho, L.N. da Costa and P.S. Pellegrini

Department of Astronomy, CNPq-Observatório Nacional
Brasil

ABSTRACT. In this paper we briefly describe some properties of lenticular galaxies in the central regions of clusters. The discussion is based on the results of an ongoing surface photometry program of SO galaxies.

I. INTRODUCTION

In recent years SO galaxies have motivated several investigations concerning their structural properties. This interest has been primarily due to the fact that lenticular galaxies have been for some time recognized to be an important test case for galaxy formation theories. In particular, studies of SO's may reveal the relative importance of environmental effects and of processes occuring at the time of galaxy formation in establishing the present-day structure of galaxies.

Recently, Dressler (1980) has given several arguments against the interpretation that SO's have evolved from spirals. In additon, he has shown that the disk to bulge ratio, D/B, and the bulge luminosity both vary with the local galactic density. These are important results because they can provide useful constraints to the theories of galaxy formation, as discussed by Dressler (1980). Thus it is worthwhile to check the reality of these observed relations by detailed surface photometry of disk galaxies in dense regions. We are presently undertaking such an investigation analysing a sample of SO galaxies selected in the central regions of the nearby Fornax cluster. The sample includes galaxies in a wide range of inclinations, providing in this manner complementary information about the structure of SO's in high-density regions. In section II we review some of the main results obtained by de Carvalho et al. (1985) for the less inclined systems. Preliminary results for the edge-on galaxies are presented in section III.

1986RMxAA..12..101D

II. PHOTOMETRIC PARAMETERS FOR THE LESS INCLINED SYSTEMS

In order to investigate the global properties of the program galaxies (Table 1), we have analyzed their light distributions along the major-axis. The galaxies in Table 1 were drawn from the ESO/Uppsala Survey of the ESO (B) Atlas where they are classified as SO's. The alternative classifications given in Table 1 are taken from the Revised Shapley Ames (Sandage and Tamman 1981) and the Second Reference Catalogue of Bright Galaxies (de Vaucouleurs 1976). The photometric parameters for the bulge and disk were derived utilizing the iterative decomposition technique introduced by Kormendy (1977), except for the edge-on systems NGC 1380A and 1381. We note that the decomposition of light profiles for galaxies in dense regions is hampered by the fact that they typically have small D/B ratios, and sometimes relatively prominent sub-components. However, de Carvalho et al. (1985) have made extensive tests to show that even for these extreme cases the profile decomposition technique can yield reliable results.

Table 1. Basic Data for Program Galaxies

NGC	R.A. (1950.0)	Dec.	Type	B_T	v (Km/s)	Sources
1351	03 28 38	-35 02.0	$SO_1(6)$/E6 SAO uncertain	12.65	1506	SV,G
1374	03 33 21	-35 23.5	E0 E0	12.30	1201	SV
1380	03 34 31	-35 08.4	$SO_3(7)$/Sa SAO	11.10	1774	SV,G
1380 A	03 34 48	-34 53.0	--------- Sab(spindle)?	----	1471	GD
1380 B	03 35 06	-35 21.0	--------- SO^+ uncertain	----	1779	SV,G
1381	03 34 36	-35 27.5	$SO_1(10)$ SAO (spindle)	12.34	1782	SV
1387	03 35 02	-35 40.2	SBO_2(pec) SO^-	11.83	1184	SV,GD
1389	03 35 17	-35 54.5	$SO_1(5)/SBO_1$ E_4	12.39	979	SV,G

Notes to table
The sources of the photoelectric data are:

SV – Sandage and Visvanathan (1978),
G – Griersmith (1978);
GD – Green and Dixon (1980).

1986RMxAA..12..101D

The aforementioned work has yielded the following results concerning the structure of the SO galaxies analyzed.

1) The observed disks show a clear tendency to being less luminous than those observed in SO's of the general field (Burstein 1979a). This is illustrated in figure 1, where we also include the more uncertain disk parameters of the edge-on galaxies.

2) The observed central disk brightnesses span a larger domain than that observed by other authors (e.g. Burstein 1979a, Boroson 1981), with some galaxies of the sample having very faint disks ($B_c(0)^{\cdot} \sim 24.5$).

3) The bulges are "normal" in the sense that they have parameters consistent with those obtained in earlier investigations, showing no evidence of being more luminous than those obtained by Burstein (1979a) for field SO's.

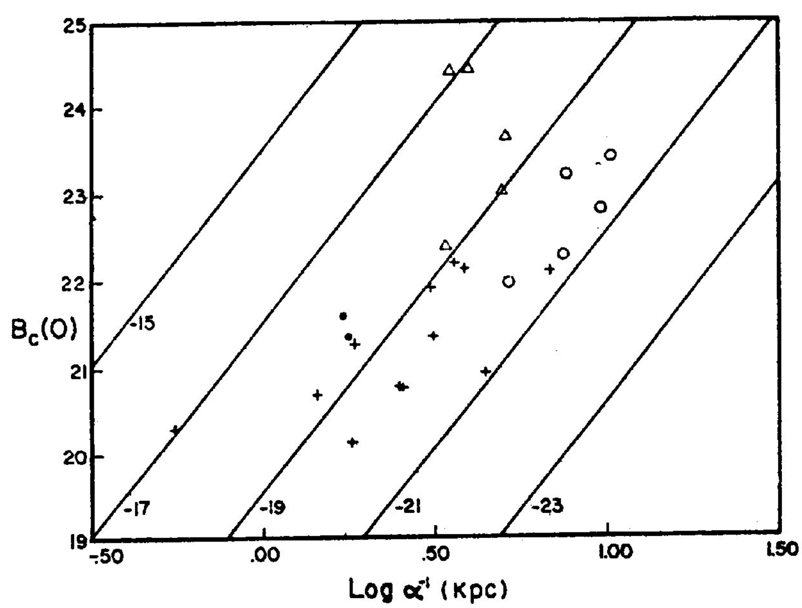


Fig. 1 Exponential disk parameters in the $B_c(0)$-log α^{-1}. The different symbols denote: (o) data from Kormendy (1977); (+) SO's studied by Burstein (1979a); (Δ) data from deCarvalho et al. (1985); (⁝) parameters for the edge-on galaxies NGC 1380A and 1381.

These results have several important implications, if they are confirmed to be a general characteristic of SO galaxies in dense regions. First, they suggest that the correlation of D/B with galactic density found

1986RMxAA..12..101D

by Dressler (1980), simply reflects the decrease of the disk luminosity with increasing local density. This effect can be accounted for by models, such as the slow disk formation model proposed by Larson et al. (1980), which view the disk formation as a slow process that can be affected by the interaction among galaxies in dense regions. Second, the observation of diffuse disks seems to argue against the existence of a relation between disk parameters, such as that proposed by Hamabe (1982), which could set useful constraints for theories of disk formation.

III. VERTICAL STRUCTURE

To complement the study of lenticular galaxies in dense regions, we are currently analyzing the edge-on galaxies listed in Table 1. Studies of edge-on systems are essential for establishing the radial extent of disks and the vertical structure of the different galactic components. It is particularly important to investigate the properties and the nature of the so called thick disks, first observed by Burstein (1979b), the interpretation of which is still controversial. These questions are very important for our understanding of formation and evolution of disk galaxies.

In figure 2 we show the major-axis surface brightness profiles of NGC 1380A and 1381, plotting the profiles along the two sides of the galaxy separately. Also shown in the figure are the best representation of an infinite exponential disk, appropriately integrated along the line of sight, matched to the observed prolile at large galactocentric distances. At these distances it is reasonable to assume that the disk makes the dominant contribution. It is interesting to note that in contrast to van der Kruit and Searle (1981) we find no evidence for an outer disk edge in neither galaxy. In fact, if it exists the cutoff radius must exceed 7.5 times the disk scale-length, α^{-1}, while in the spirals analyzed by van der Kruit and Searle they occur at an average radius of 4.7 α^{-1}. In the figure we also show the light distribution after the subtraction of the disk light, which reveals the presence of underlying components.

1986RMxAA..12..101D

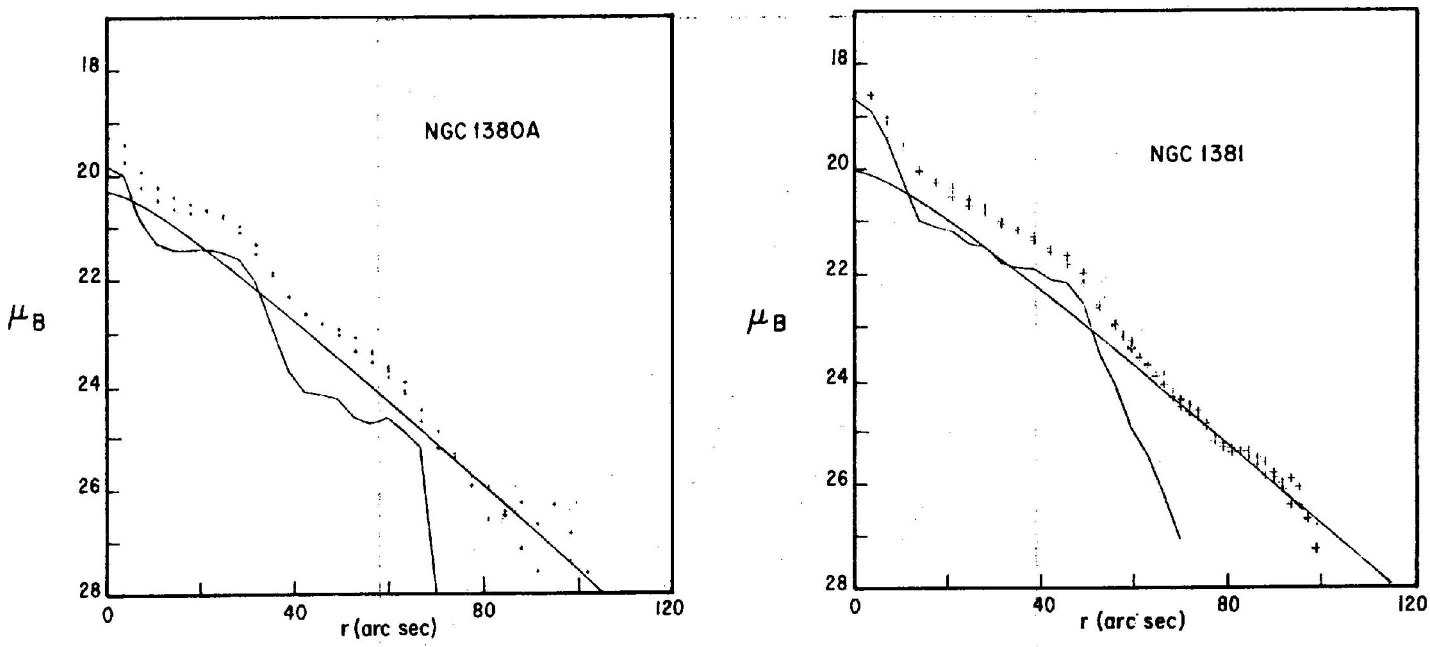
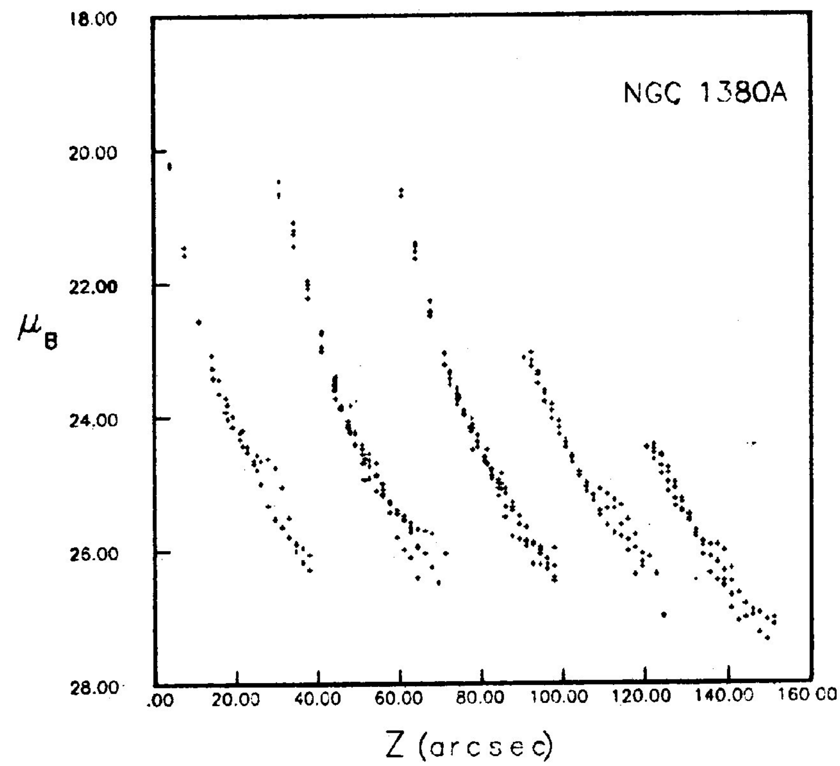


Fig. 2 Observed luminosity profiles along the major-axis for: (a) NGC 1380A and (b) NGC 1381. Also shown are the infinite exponential disk model and the residual light after its subtraction.

The light profiles perpendicular to the galactic plane are shown in figure 3, where we plot at each galactocentric distance the profiles obtained at the four quadrants. The overall shape of these profiles resemble those presented by Burstein (1979b), showing at large z a similar behaviour of Burstein's thick disks. In order to analyze the perpendicular profiles we have adopted the locally isothermal, self-gravitating disk model proposed by van der Kruit and Searle (1981). Following these authors, we assume that the vertical scale height is constant with radial distance. In this case the parameters for the disk can be determined from the fits of the major-axis profile and the perpendicular profiles, at large galactocentric distances. We utilize the disk model to estimate the light contribution from the disk to the observed z-profiles. Subtracting out this contribution we can determine the vertical structure of the underlying components. Tentative values for the scale heights of the identified bar of NGC 1380A (0.27 Kpc) and the lens of NGC 1381 (0.53 Kpc) are consistent with those obtained recently by Wakamatsu and Hamabe (1984) for the lens and the bar of NGC 4762. The derived values for the central brightnesses of these components are also in agreement with the values obtained by these authors.

1986RMxAA..12..101D



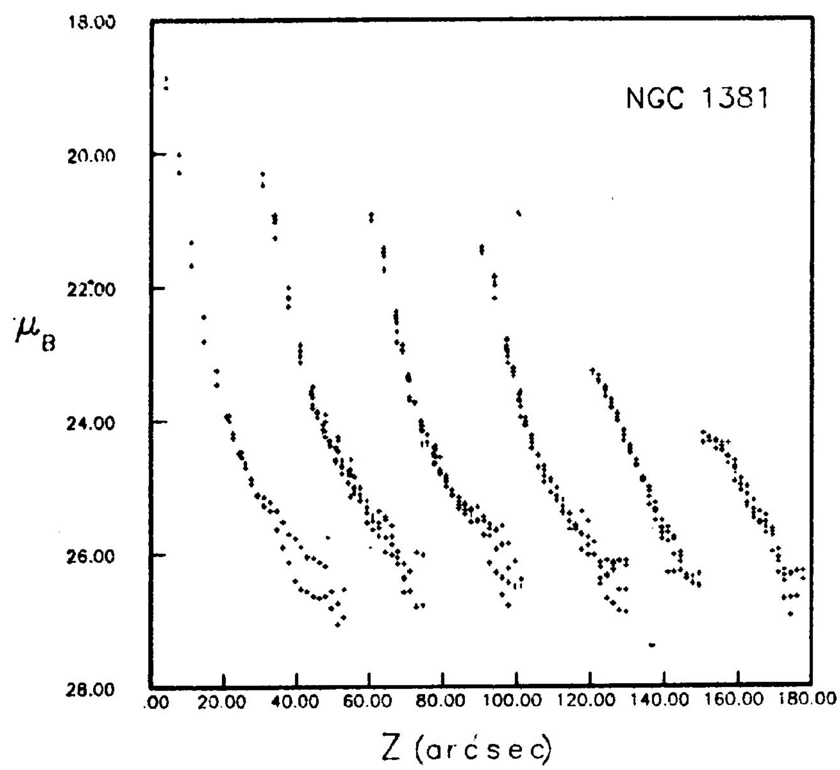


Fig. 3 Observed luminosity profiles perpendicular to the galactic plane at different galactocentric distances.

1986RMxAA..12..101D

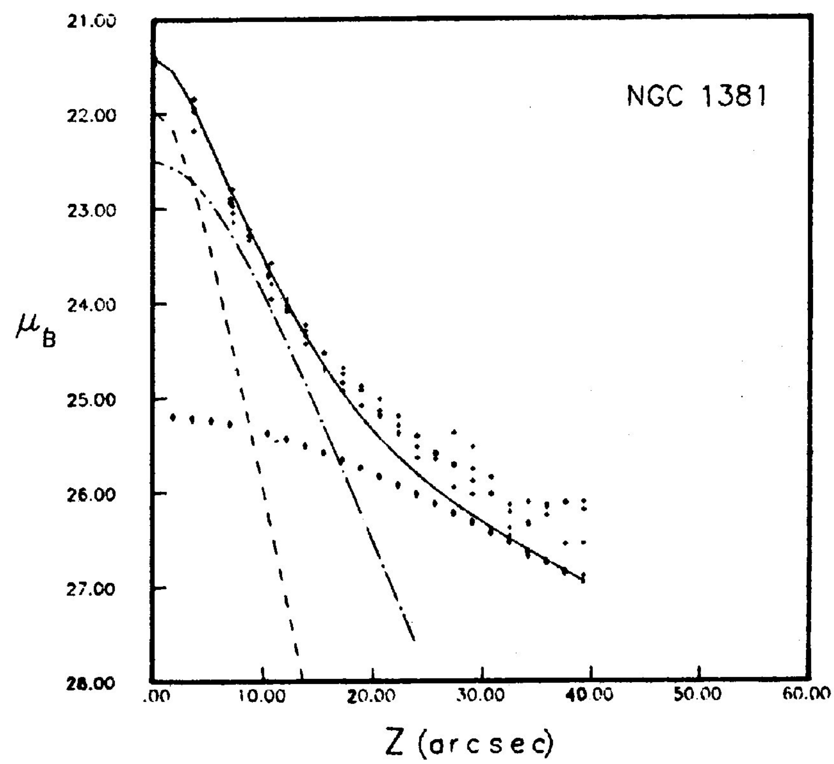


Fig. 4 Decomposition of z-profile of NGC 1381 at r=40". The symbols denote: (+) observed profile; (◊) bulge contribution. The dot-dashed line represents the contribution of the isothermal disk model, while the dashed line represents the model fit for the intermediate component. The solid line is the total light distribution accounted for by the model.

In figure 4 we show the relative contributions of the bulge, lens and disk to the observed z-profile of NGC 1381 at r=40", where the lens is most prominent along the major axis. In estimating the bulge contribution we have assumed, like Burstein (1979b), that it can be represented by an uniform axial ratio spheroid. Comparison of the observed profile with the sum of the individual contributions shows that for $z > 20"$ the former is systematically brighter. This excess is well described by an exponential law with an estimated scale-height of the order of 1.4 Kpc, consistent with the value obtained by Tsikoudi (1979) for NGC 3115. We should point out that NGC 1381 has $D/B < 1$ and therefore it is unlikely that the observed light excess is due to a global deformation of the bulge in response to the gravitational field of the disk. It is worth mentioning that the axial ratio of the isophotes at faint light levels is the same for NGC 1380A and 1381, being slightly larger than 0.4 at $u_B \sim 26.5$. This result is interesting because if one interprets the

1986RMxAA..12..101D

thick disk as the response of the bulge to the flat disk potential, one should expect a relation between the axial ratio of the outer isophotes and D/B, as demonstrated by Monet et al. (1981). A more detailed discussion of the above results will be presented in a future contribution.

REFERENCES

Burstein, D. 1979a, Ap. J., 234, 435.
Burstein, D. 1979b, Ap. J., 234, 829.
Boroson, T. 1981, Ap. J. Suppl., 46, 177.
de Carvalho, R. R., da Costa, L.N., and Pellegrini, P. S. 1985, to be published in Astr. Ap.
de Vaucouleurs, G., de Vaucouleurs, A., and Corwin, H. G. 1976, Second Reference Catalogue of Bright Galaxies (Austin: University of Texas Press).
Dressler, A. 1980, Ap. J., 236, 351.
Hamabe, M. 1982, Pub. Astr. Soc. Japan, 34, 423.
Kormendy, J. 1977, Ap. J., 217, 406.
Kruit, P.C. van der, and Searle, L. 1981, Astr. Ap., 95, 105.
Larson, R.B., Tinskey, B. M., and Caldwell, C.N. 1980, Ap. J., 237, 692.
Monet, D.G., Richstone, D.O., and Schechter, P.L. 1981, Ap. J., 245, 454.
Sandage, A., and Tamman, G. 1981, A Revised Shapley-Ames Catalog of Bright Galaxies (Carnegie Institution of Washington, Washington, D.C.).
Tsikoudi, V. 1979, Ap. J., 234, 842.
Wakamatsu, K., and Hamabe, M. 1984, Ap. J. Suppl., 56, 283.

R.R. de Carvalho, L.N. da Costa, and P.S. Pellegrini: Departamento de Astronomia CNPq/Observatório Nacional, Rua Gen. Bruce 586, 20921, Rio de Janeiro, RJ Brasil.