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ASTRONOMY AND ASTROPHYSICS

An extragalactic database

III. Diameter reduction

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Abstract. New photometric diameters have been used to study transformation formulae to reduce all visual diameters to a common standard system (isophotal diameter at the limiting surface brightness of 25 B mag arcsec^{-2}). A new interpretation of these transformations gives a good explanation of puzzling results found in earlier papers. The curvatures in a log-log plot are explained by the incompleteness of catalogues. Besides, the ESGC catalogue (Corwin & Skiff 1990) which covers the equatorial band, allows us, for the first time, to test the North-South homogeneity of the reduction.

The coefficients used in the reduction formulae have also been derived using empirical arguments. Both methods are in fair agreement. In addition, a correlation between the coefficients used for diameter and axis ratio also gives us confidence in our formulae.

Finally, the standard error associated with each catalogue, has been found to depend upon the diameter, which seems more realistic than the previous approximation of a constant dispersion.

Key words: galaxies – data analysis – catalogue

1. Introduction

The preparation of the Third Reference Catalogue (RC3; de Vaucouleurs et al. 1990) and of the Catalogue of Principal Galaxies (PGC; Paturel et al. 1989a, 1989b) and some new facts compel us to reconsider old formulae used for reduction of visual diameters to the standard D_{25} system. These facts are the following:

1) We collected new standard diameters from surface photometry. The new sample contains now 608 diameters at the 25 mag arcsec^{-2} level (in the last study our standard sample contained only 359 diameter measurements; see Fouqué and Paturel 1983).

2) We measured 733 aperture diameters at the 25 mag arcsec^{-2} level for galaxies with photometric magnitudes measured through several apertures.

3) Lauberts & Valentijn (1989) published a large sample of diameters at the 25 mag arcsec^{-2} measured from photographic surface photometry. This new sample contains 13845 diameters which were used as standard.

4) Some new catalogues of visual diameters have been added to the Extragalactic Data Base (Paturel et al. 1988). The ESGC (Extension to the Southern Galaxy Catalogue; Corwin & Skiff 1990) which is an extension of the SGC (Southern Galaxy Catalogue, Corwin, de Vaucouleurs & de Vaucouleurs 1985) is very important because it covers the equatorial band with common parts with both UGC and ESO catalogues (Uppsala General Catalogue, Nilson 1973; ESO Uppsala Survey of the ESO(B) Atlas, Lauberts 1982).

5) New understandings about the form of the reduction formulae allow us to interpret our former results (Paturel 1975a; 1975b; Fouqué & Paturel 1985; Paturel et al. 1987).

1.1. Form of the relation for diameter reduction

Whatever the shape of the brightness profile of a galaxy is, it is possible to demonstrate that the transformation of a diameter system D_1 at a brightness limit B_1 into another diameter system D_2 at a brightness limit B_2 has the form (under the assumption that B_1 and B_2 do not differ too much):

$$\log D_1 = \log D_2 + f(B_1, B_2)$$

However, it was clearly found that the slope $a = \delta(\log D_1)/\delta(\log D_2)$ was significantly different from one for some catalogues (Bottinelli et al. 1973). This unexpected result was interpreted by the fact that the limiting surface brightness for these catalogues was not a constant (Paturel 1975b). This effect was called a diameter-effect, to express that the limiting surface brightness was a function of $\log D$. Some catalogues (MCG, UGC etc.) had a normal diameter effect (the limiting surface brightness is fainter for large galaxies), some catalogues (e.g. Holmberg's catalogue, 1958, or SGC) even showed an inverse diameter effect.

Thus, several empirical forms were used to account for this slope. The most general form used for diameter reduction is (de Vaucouleurs et al. 1976; RC2):

$$\log D_{25}(\mathrm{STD1}) = a \log(D + c) + b. \quad (1)$$

Fouqué & Paturel (1985) tried to use the c value recommended by de Vaucouleurs in 1959 (i.e. c calculated as a function of the plate scale). In practice, the use of c means also that the limiting surface brightness depends on $\log D$, but with a dependence leading to a curvature near small diameters in the log-log plot. With this

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interpretation, the c value should be a constant for a given plate scale. Unfortunately, it was shown (Paturel et al. 1987), that it is not the case. For instance, we found $c = -0.3$ for early-type galaxies in the ESO catalogue, but $c = 0.3$ for spirals of this same catalogue. Thus, c is not a magic value transforming visual diameters into photometric ones.

We decided to solve the general form using a non-linear regression program. After a lot of trials, we found that the c value is very sensitive to the distribution of points and we definitively confirmed that it is not a constant for a given plate scale.

In summary, we have to answer four questions:

1) why the slope a differs from 1?

2) why some catalogues have an inverse diameter-effect ($c < 0$)?

3) why the log-log plot shows a curvature for small diameters?

4) why this curvature is not the same for early and late-type galaxies?

1.2. New interpretation

This new interpretation is based on two facts:

1) The dispersion in $\log D$ increases with decreasing diameters. In previous studies, we always assumed that the mean error on $\log D$ was a constant. This assumption meant that error on diameters increases with increasing diameters; this is just the contrary of what can be expected. Besides, all the unrestricted $\log D - \log D$ plots show clearly that the mean error is larger near small diameters. For instance, in the Fig. 1a the relation $\log D_{25}$(STD) vs. $\log D$(MCG) is given. This effect is well visible.

2) Different catalogues or lists of diameters have not necessarily the same completeness limit in $\log D$. In our previous papers it was shown that a cut-off is needed when one sample is diameter limited. Without cut-off the solution is biased. Figures 1a and 1b illustrate two real opposite cases, when the completeness limit first appears either on Y-axis (Fig. 1a) or on X-axis (Fig. 1b). In our new interpretation of $\log D - \log D$ relationships, if c differs from zero (or equivalently, if a differs from 1), this is the result of a bias. When one compares two samples with different completeness limit in $\log D$, the remaining representative points are located in a distorted area. More exactly, the bias produces a curvature where the dispersion in $\log D$ increases. If a linear regression is fitted, the resulting slope differs from 1. This bias is easier to understand from graphics (Fig. 2).

We can now answer the four questions asked at the beginning. We have already understood why the slope may differ from 1 or why a curvature may appear. If a catalogue reaches diameters smaller than the ones of the standard sample, that will produce an apparent diameter-effect (i.e. a slope less than 1 in $\log D_{25}$ vs $\log D$ diagram); MCG provides a good example of that case (Fig. 1a). On the contrary, if a catalogue does not reach small galaxies, it will result in an inverse diameter-effect (i.e. slope greater than 1 in the same diagram); it is the case for SGC diameters (Fig. 1b) or for Holmberg's diameters; note however that, in these particular cases, the problem could be complicated by the fact that diameters correspond, on the mean, to a limiting surface brightness very different from the standard one at 25 mag arcsec^{-2}; second order terms may intervene.

Similarly, we interpret the variation of c with the morphological type by the fact that the completeness (in $\log D$) is better for spiral galaxies than for early types galaxies.

The conclusion is that appropriate cuts have to be used to remove any visible curvature in log – log scale. That will be done in the following way: 1) for each catalogue the completeness limit $\log D$(lim) will be determined (Fig. 5). 2) a cut-off is applied at this limit while another cut-off is applied on the standard $\log D_{25}$ sample. This last cut-off is calculated as $\log D(\text{lim}) + \delta(\log D)$, where $\delta(\log D)$ is the zero-point difference between the studied

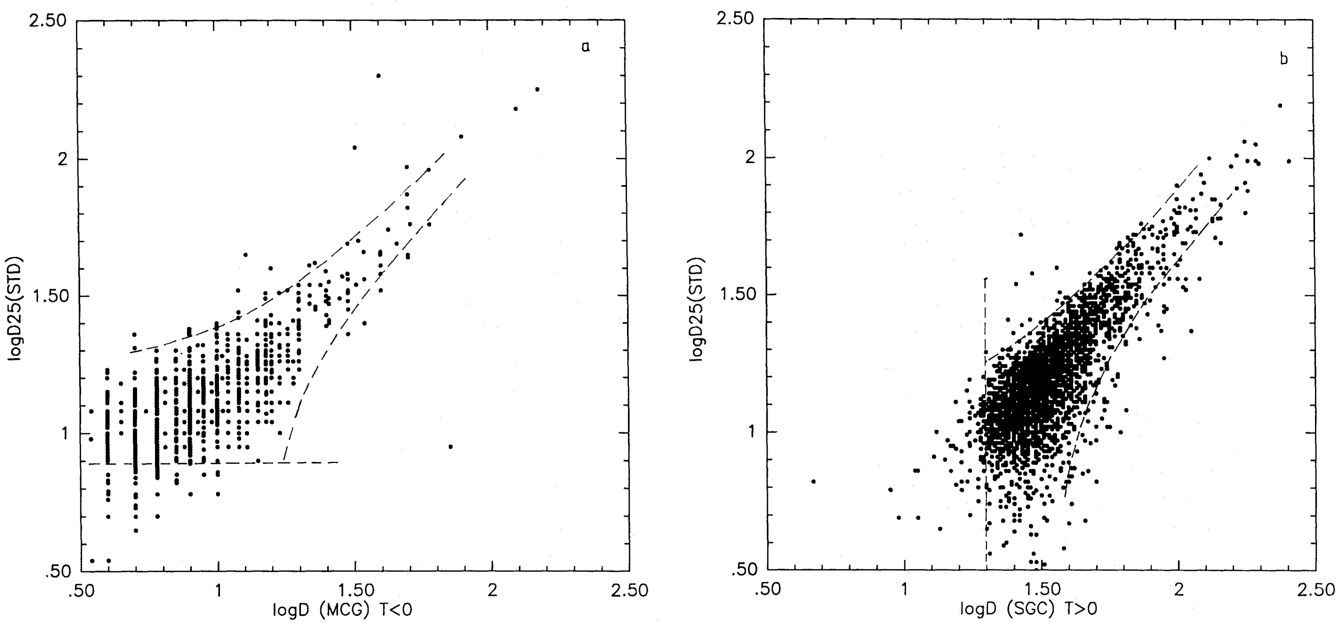

Fig. 1a and b. $\log D - \log D$ plots show that the dispersion in $\log D$ increases when diameter decreases. Besides, the effect of the completeness limit is visible: **a** when the limit appears first on the Y-axis, **b** when the limit appears first on the X-axis. The points are located in a distorted area, depending on completeness limits

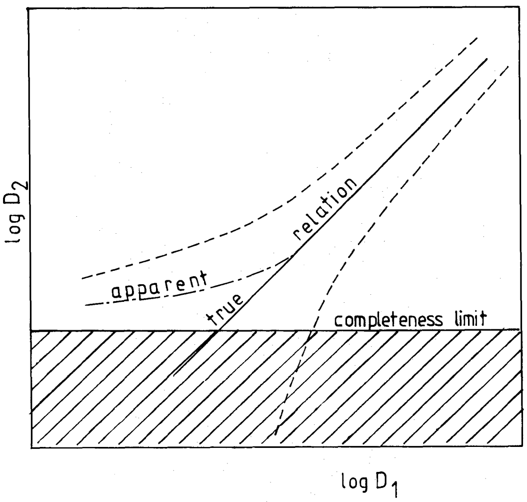

Fig. 2. Illustration to show how a curvature can be produced with a diameter-limited sample. The curvature comes from the fact that the error increases towards small diameters where the sample used for comparison becomes incomplete. The remaining points follow a curved relationship

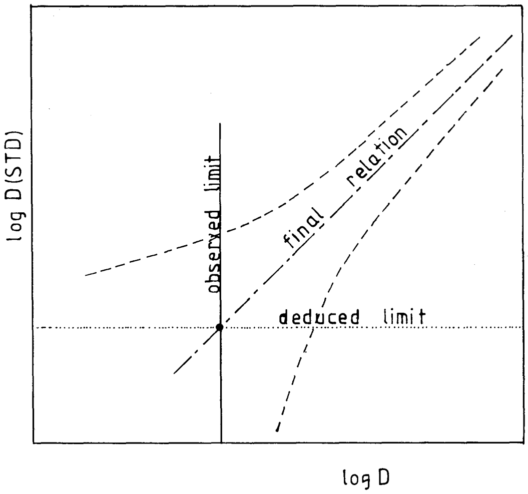

Fig. 3. Illustration of how to calculate the cut-off of the sample on both axes: On the x-axis the limit is given by the completeness limit of the catalogue. On the y-axis (axis where the standard $\log D_{25}$ diameters are plotted) the cut-off is given by the intersection of the x-cut-off with the final regression line. This solution is obtained after one iteration

catalogue and the standard system as determined from a preliminary comparison. The final solution is obtained after one iteration. This procedure is illustrated in Fig. 3.

The use of cut-offs has an important consequence. When the total sample is restricted to large diameters, the apparent error is smaller than the true one and cannot be used to estimate it. Therefore, the actual mean error cannot be deduced just from the standard deviation calculated using the restricted sample. Besides, we will try to represent how the mean error varies with the diameter.

1.3. Form of the relation for axis ratio reduction

For axis ratio we will use the simplest relation (de Vaucouleurs et al. 1976; RC2)

$$\log R_{25} = a' \log R \tag{2}$$

with $R = D/d$ and $R_{25} = D_{25}/d_{25}$, where d denotes minor axis. This relation satisfies the necessary conditions:

$R = 1 \Rightarrow R_{25} = 1$

$R > 1 \Rightarrow R_{25} > 1.$

Obviously, axis ratios do not require cuts as diameters do.

1.4. Reduction procedure

In the next section, we build a sample of D_{25} diameters by testing and merging the three basic standard samples D_{25}(SP) from surface photometry, A_{25} from photoelectric aperture photometry (Buta, private communication) and D_{25}(LV) from Lauberts and Valentijn photographic surface photometry (1989). This standard sample is designated as STD1.

Then, in the third section, we use STD1 to reduce the UGC to the D_{25} system. Using the STD1 and the reduced-UGC, we build a larger standard sample (STD2) of D_{25} diameters. At this stage, it is possible to test if our reduction procedure is homogeneous over both hemispheres. That is done by reducing the ESGC catalogue independently, in the North and in the South regions. The solution will be considered as correct if northern and southern reduction formulae are compatible. In the fourth section, the STD2 sample is used to deduce reduction formulae for all blue external diameters gathered in our Extragalactic Data Base. Some poorly determined diameters will be tentatively reduced. After that, the coefficients of the reduction formulae are verified by independent tests. Finally, in the fifth section, errors are estimated for each catalogue and we look for mean surface brightness residuals.

2. The STD1 sample

608 D_{25}-diameters from surface photometry [D_{25}(SP)] are used as a basic Standard system. They come from several sources (Fouqué & Paturel 1983; Davies & Kinman 1984; Michard 1985; Pence & de Vaucouleurs 1985; Buta & Corwin 1986; Capaccioli et al. 1986; Cornell et al. 1987; de Carvalho & da Costa 1988). Because these diameters have been measured by different authors and reduced in different ways, it is difficult to suspect them of having any systematic error. However, some of them known to be of poor quality have been excluded (e.g. Fraser 1977) if they are not confirmed by another measurement. Moreover, two sources, (Atlas de Cordoba by Sersic and the paper by Carvalho and da Costa) were found to have large discrepancies. Both sources were excluded from the standard system.

In the preparation of the forthcoming RC3 catalogue, we made a compilation of aperture photoelectric measurements. For galaxies measured trough several apertures, an aperture-diameter A_{25} is derived from the brightness profile. Such a method gives accurate diameters if the aperture is large enough to reach the region around 25 B mag arcsec^{-2}. Only the best measurements were used.

Such A_{25} diameters must be corrected for an inclination effect. This effect has been looked for using standard $\log D_{25}$ as a reference. A direct least-square solution gives the corrected A^c_{25}

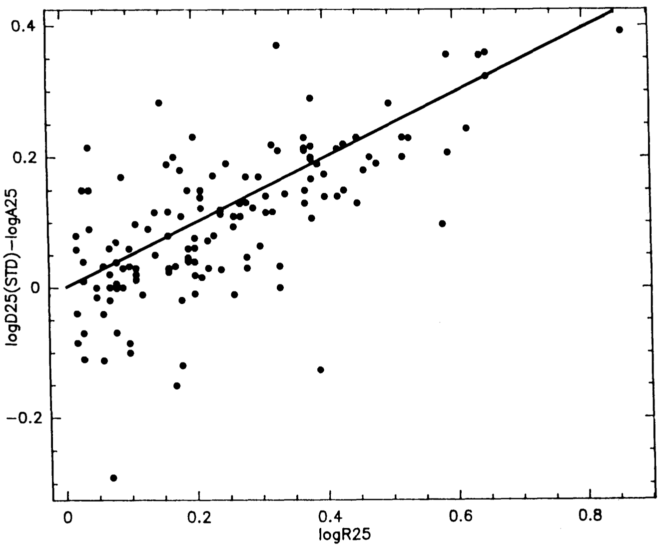

Fig. 4. The difference between D_{25} (STD) and A_{25} as a function of axis ratio. From this plot we concluded that the aperture diameter A_{25} depends on the axis ratio

(Fig. 4):

$$\log A_{25}^{c} = \log A_{25} + 0.485 \log R_{25} \quad (n=146)$$
$$\pm 0.040$$

where R_{25} is the axis ratio D_{25}/d_{25} calculated from our previous relations. Note that a solution in $(\log R_{25})^2$ has been tested for but has been rejected because it gave a lower correlation coefficient. G. de Vaucouleurs commented that a natural slope of 0.5 is expected from the simple relation $A_{25}^2 = D_{25} d_{25}$. We now perform a 2 by 2 comparison between D_{25}(SP), D_{25}(LV) and A_{25}^{c} diameters. No scale effect has been found and none of the zero points is significantly different from zero. From the standard deviations obtained for each comparison:

$$\sigma[\log A_{25}^{c} - \log D_{25}(\mathrm{LV})] = 0.076$$

$$\sigma[\log A_{25}^{c} - \log D_{25}(\mathrm{SP})] = 0.060$$

$$\sigma[\log D_{25}(\mathrm{LV}) - \log D_{25}(\mathrm{SP})] = 0.085,$$

we obtain the individual standard deviation (see de Vaucouleurs & Head 1968; Paturel 1975a):

$$\sigma(\log A_{25}^{c}) = 0.04$$

$$\sigma[\log D_{25}(\mathrm{LV})] = 0.07$$

$$\sigma[\log D_{25}(\mathrm{SP})] = 0.05.$$

The standard sample STD1 has been obtained by calculating for each object the weighted mean diameter from each available diameter, where the weight is the inverse square of individual mean error. The surface photometry is the only source of standard axis ratios.

3. Reduction of UGC. The STD2 sample

Contrarily to what was the rule for years, the standard sample of the southern hemisphere is larger than the northern one, because of new photometric measurements by Lauberts & Valentijn (1989). Fortunately, the UGC visual diameters are good enough to constitute a secondary standard sample after proper reduction.

3.1. Solution for blue-UGC

The limit of completeness claimed by Nilson for the UGC is $\log D(\mathrm{lim}) = 1.00$. This is clearly confirmed in Fig. 5a. The adopted

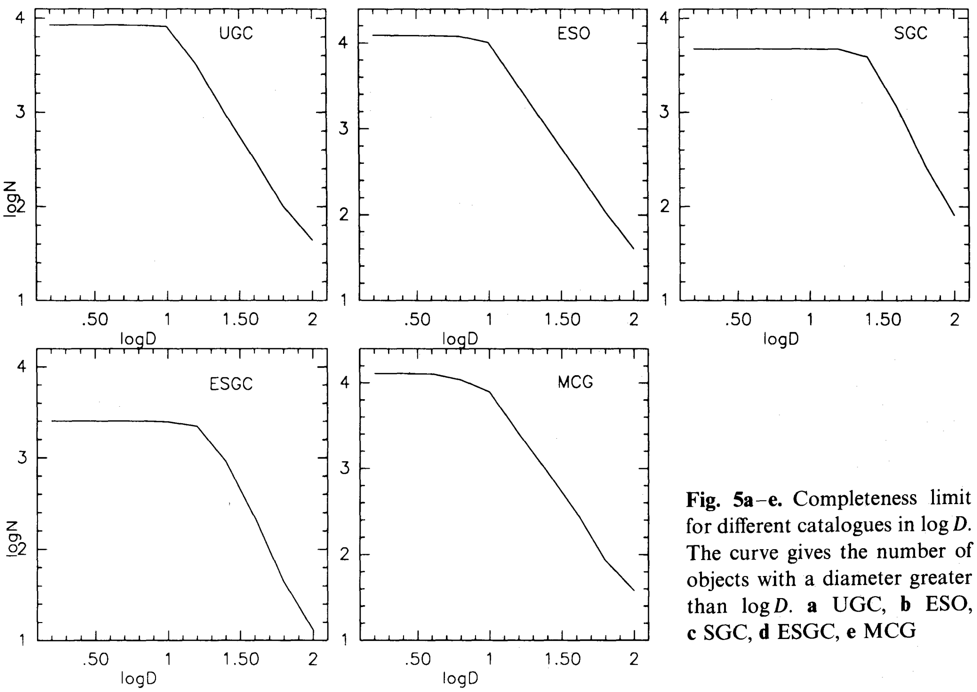

Fig. 5a–e. Completeness limit for different catalogues in $\log D$. The curve gives the number of objects with a diameter greater than $\log D$. **a** UGC, **b** ESO, **c** SGC, **d** ESGC, **e** MCG

cut-off is:

for $T \geq 0$ x-axis $\log D_{UGC} \geq 1.00$

y-axis $\log D_{25} \geq 0.97$

for $T<0$ x-axis $\log D_{UGC} \geq 1.00$

y-axis $\log D_{25} \geq 0.99$.

The slopes are not significantly different from one. The final result is then:

$T \geq 0$ $\log D_{25}(\mathrm{STD1}) = \log D_{UGC} - 0.038 \pm 0.004$ $\sigma = 0.086$ $n = 411$

$T<0$ $\log D_{25}(\mathrm{STD1}) = \log D_{UGC} + 0.006 \pm 0.008$ $\sigma = 0.098$ $n = 159$.

The following results are obtained for axis ratio reduction:

$T \geq 0$ $\log R_{25}(\mathrm{STD1}) = 0.98 \pm 0.03 \log R_{UGC}$ $\sigma = 0.08$ $n = 177$

$T<0$ $\log R_{25}(\mathrm{STD1}) = 0.95 \pm 0.04 \log R_{UGC}$ $\sigma = 0.06$ $n = 72$.

3.2. *Test of the STD2 sample with the ESGC*

Unpublished tests showed that a North/South effect was present in our previous reduction formulae. This fact is not surprising because our relations were based on two independent sets of standard diameters, with only few objects in common. Today, homogeneity of the reduction over North and South hemispheres can be achieved. Indeed:

1) we have more standards covering both hemispheres;

2) the ESGC, which covers the equatorial band, can be used to test the homogeneity.

By reducing Northern and Southern parts of the ESGC from the STD2 we must obtain the same reduction formulae for both regions. Using the cut-off $\log D_{ESGC} \geq 1.26$ from Fig. 5d, the results obtained for ESGC are the following:

ESGC for $T \geq 0$

NORTH $\log D_{25}(\mathrm{STD2}) = \log D_{ESGC} - 0.189 \pm 0.004$ $\sigma = 0.084$ $n = 405$

SOUTH $\log D_{25}(\mathrm{STD2}) = \log D_{ESGC} - 0.184 \pm 0.006$ $\sigma = 0.088$ $n = 214$

ESGC for $T<0$

NORTH $\log D_{25}(\mathrm{STD2}) = \log D_{ESGC} - 0.172 \pm 0.010$ $\sigma = 0.100$ $n = 96$

SOUTH $\log D_{25}(\mathrm{STD2}) = \log D_{ESGC} - 0.142 \pm 0.010$ $\sigma = 0.086$ $n = 71$.

There is no significant North-South difference. Then, the ESGC reduction can be done using the following relations:

$\log D_{25}(\mathrm{STD2}) = \log D_{ESGC} - 0.186$ for $T \geq 0$

$\log D_{25}(\mathrm{STD2}) = \log D_{ESGC} - 0.157$ for $T<0$.

For axis ratios the results are the following:

$T \geq 0$ $\log R_{25}(\mathrm{STD2}) = 1.26 \pm 0.02 \log R_{ESGC}$ $\sigma = 0.12$ $n = 624$

$T<0$ $\log R_{25}(\mathrm{STD2}) = 1.11 \pm 0.06 \log R_{ESGC}$ $\sigma = 0.10$ $n = 191$.

4. Reduction of other catalogues

4.1. *The result*

Several lists or catalogues give blue external diameters:
ESO-Uppsala Survey of the ESO(B)Atlas by Lauberts
Morphological Catalogue of Galaxies by Vorontsov-Velyaminov et al. (1962–1968)
Southern Galaxy Catalogue by Corwin (1985)
Holmberg photographic diameters (Holmberg 1958)
Catalogue of Selected Non-UGC galaxies (Nilson 1974)
KUG galaxies (Takase & Miyauchi-Isobe 1984, 1985ab, 1986ab, 1987ab, 1988, 1989ab)
VCC galaxies in the Virgo area (Binggeli et al. 1985)
Karatchenseva isolated galaxies (Karatchenseva 1973)
Kazarian galaxies (Kazarian 1979ab, 1980, 1982, 1983)
Tololo galaxies (Smith et al. 1976).

All are reduced in the same way by comparing with STD2 diameters (STD1 + reduced UGC). The results are gathered in Table 1a and 1b for diameters and axis ratios respectively. All previous results are repeated too, so that Table 1a and 1b give a summary of our adopted conversion formulae. In Table 1a the completeness limit in $\log D$ is given for each catalogue. This limit is used to calculate the cut-off for both x and y axes, as explained before.

Almost all these results confirmed that the slope a of the general relation, does not differ significantly from one when the proper cut-off has been used on x and y axes. However there is a major exception for Holmberg's catalogue which has a slope definitely different from one. This may be explained by the fact that Holmberg's diameters reach fainter brightness limit. If this explanation is correct, it may suggest that the tendency also visible on SGC diameters (which also reach very faint brightness limit) is real.

4.2. *Independent test of the b coefficients*

We developed a new test of the diameter reduction formulae. The principle is the following:

If a catalogue contains a large number of objects per unit of solid angle, that means that it reaches small galaxies. If D_{25}(limit) is the standard diameter at which the catalogue is complete, then we have:

$$N \sim D_{25}(\mathrm{limit})^{-3}$$

where N is the number of galaxies per unit of solid angle, for this particular catalogue.

Using our simple reduction formula $\log D_{25} = \log D + b$, we derive easily

$$N \sim k^{-3} D(\mathrm{limit})^{-3}$$

where $k = 10^b$. Then, applying this equation to two catalogues

Table 1a. Summary of reduction formulae for all diameters studied in this paper

Catalogue		a	b	n	$\log D$ (limit)
UGC	$T \geq 0$	1	-0.038 ± 0.004	411	1.0
	$T < 0$	1	0.006 ± 0.008	159	
ESO	$T \geq 0$[a]	1	-0.080 ± 0.001	6017	1.0
	$T < 0$[a]	1	-0.032 ± 0.002	1406	
ESGC	$T \geq 0$	1	-0.187 ± 0.005	619	1.3
	$T < 0$	1	-0.157 ± 0.007	167	1.3
SGC	any T	1.06 ± 0.01	-0.38 ± 0.02	2312	1.4
MCG	$T \geq 0$	1	0.037 ± 0.001	5064	1.0
	$T < 0$	1	0.116 ± 0.005	393	
HOLM	any T	1.11 ± 0.02	-0.35 ± 0.04	190	1.6
non-UGC	any T	1	0.000 ± 0.001	129	1.3
KUG	any T	1	0.021 ± 0.006	130	1.2
VCC	any T	1	-0.147 ± 0.004	280	(1.4)
KAR-isl	any T	1	-0.005 ± 0.004	372	1.0
KAZA	any T	1	0.09 ± 0.02	29	1.0:
TOLOLO	any T	1	0.12 ± 0.02	6	1.0:

[a] After correction for the time effect (LN-effect) found in a previous paper (Paturel et al. 1987) according to the relation $\log D^c_{\rm ESO} = \log D_{\rm ESO} - 0.010$ (LN-5) where LN is the list number of the original publication of ESO-B diameters.

referenced by i and j, it comes:

$$k_j/k_i = [N_i/N_j]^{1/3} D_i(\text{lim})/D_j(\text{lim}) \quad (3)$$

or

$$b_j - b_i = 1/3 \log(N_i/N_j) + \log(D_i(\text{lim})/D_j(\text{lim})). \quad (4)$$

N_i/N_j are calculated from the number of galaxies (up to the diameter limit) and the solid angle covered by each catalogue (Table 2). $D_i(\text{lim})/D_j(\text{lim})$ are known from the completeness limits in $\log D$ (see Table 1 and Fig. 5). We made all two by two comparisons for the largest catalogues (i.e. UGC, ESO, SGC, ESGC, MCG). In Table 3 and Fig. 6, the $b_j - b_i$ values from both Table 1a and Rel. 4 are compared. Where separate relations for $T < 0$ and $T \geq 0$ have been adopted in Table 1a, a weighted mean of the b_i has been used. Moreover, when the slope a (in Table 1a) differs from 1, the adopted b_i has been the one obtained by forcing a to 1. The good agreement confirms that our reduction coefficients are correct, at least as a first approximation. In some cases (Holmberg and SGC), a more sophisticated method, taking into account second order effect, should probably be used.

The second test is less powerful but may have a physical meaning. A significant relationship has been found (Fig. 7) between the coefficient a' (in Relation 2) and the coefficient b (in Relation 1, where $a = 1$ and $c = 0$). This relation means that

Table 1b. Summary of reduction formulae for axis ratios studied in this paper. Note that $\sigma_{\rm cat}$ has been calculated from the observed standard deviation assuming that the mean error of all standard axis ratios is 0.05

Catalogue		a'	$\sigma_{\rm cat}$	n
UGC	$T \geq 0$	0.98 ± 0.03	0.06	177
	$T < 0$	0.95 ± 0.04	0.03	72
ESO	$T \geq 0$[a]	1.04 ± 0.07	0.08	48
	$T < 0$[a]	0.99 ± 0.06	0.03	99
ESGC	$T \geq 0$	1.26 ± 0.02	0.11	624
	$T < 0$	1.11 ± 0.06	0.08	191
SGC	$T \geq 0$	1.41 ± 0.01	0.11	3116
	$T < 0$	1.42 ± 0.03	0.10	1146
MCG	$T \geq 0$	0.949 ± 0.004	0.09	8499
	$T < 0$	0.91 ± 0.01	0.09	1159
HOLM	any T	1.21 ± 0.03	0.07	209
non-UGC	any T	1.04 ± 0.02	0.08	276
KUG	any T	0.88 ± 0.02	0.11	403
VCC	any T	0.89 ± 0.02	0.06	303
KAR	any T	0.80 ± 0.02	0.09	448
KAZA	any T	0.92 ± 0.05	0.12	89
TOLOLO	any T	0.81 ± 0.11	0.16	30

[a] After correction for the time effect (see Table 1a) using the relation:

$$\log R^c_{\rm ESO} = \log R_{\rm ESO} + 0.004(\text{LN} - 5)$$

where LN is the list number of the original publication of ESO-B diameters.

Table 2. Solid angle Ω covered by the largest catalogues and corresponding normalized density N (in steradian^{-1}). The number of galaxies up to the completeness limit is denoted by n

	Ω (sr)	n	N (sr^{-1})
UGC	6.5	8128	1251
ESO	4.4	10233	2326
SGC	4.5	3802	845
ESGC	2.5	1778	711
MCG	9.7	7943	819

Table 3. Observed and predicted difference $b_i - b_j$ of two coefficients of reduction. Note that for SGC the b value is the one obtained by forcing $a=1$

i	j	$b_j - b_i$ from Table 1	$b_j - b_i$ from Eq. (4)
UGC	ESO	−0.045	−0.09
UGC	SGC	−0.254	−0.34
UGC	ESGC	−0.141	−0.21
UGC	MCG	0.069	−0.06
ESO	SGC	−0.209	−0.25
ESO	ESGC	−0.096	−0.13
ESO	MCG	0.114	0.15
SGC	ESGC	0.110	0.12
SGC	MCG	0.423	0.40
ESGC	MCG	0.210	0.28

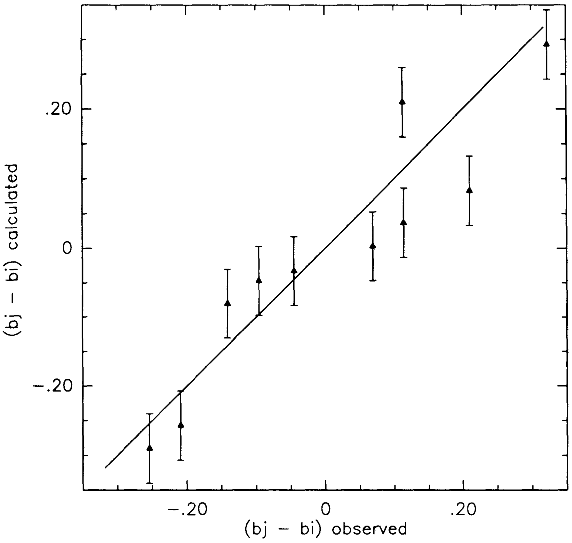

Fig. 6. Observed and predicted difference $b_i - b_j$ of two coefficients of reduction. Observed differences deduced from Table 1a are plotted on y-axis; differences predicted from Rel. 4, are plotted on x-axis

galaxies look rounder when a faint limiting surface brightness is reached. If the b's coefficients were wrong, such a relation would not exist.

5. Estimation of errors on diameters

5.1. Mean errors on $\log D_{25}$

In previous studies, we always assumed that the mean error on $\log D$ was a constant. This assumption means that the errors on diameters increase with increasing diameters. Besides, all the unrestricted $\log D - \log D$ plots show clearly that the mean error is larger near small diameters. This fact has been used to explain curvatures in the previous sections. Thus, we will try to take the variation of the mean error with the diameter into account.

From unrestricted $\log D - \log D$ plots (i.e. plots without cut-off) we measured the dispersion σ of $\log D_{25}$ around different $\log D_{25}$ values. Then, σ was plotted versus $\log D_{25}$ (Fig. 8). The best representation of this curve has been given by the empirical formula:

$$\sigma = K D_{25}^{-0.65} \quad (D_{25} \text{ in arcmin})$$

where K is a constant depending on the considered catalogue. From the regressions made in the previous sections we obtain for each catalogue an observed value of σ at a mean value of the diameter, and then we can derive the corresponding value of K. The results are given in Table 4. To avoid some unrealistic low values of σ for large diameters, we added quadratically an asymptotic dispersion $\sigma_0 = 0.02$.

5.2. Mean surface brightness residuals

From a theoretical point of view, it is expected that the relation of diameter conversion depends on mean surface brightness. The

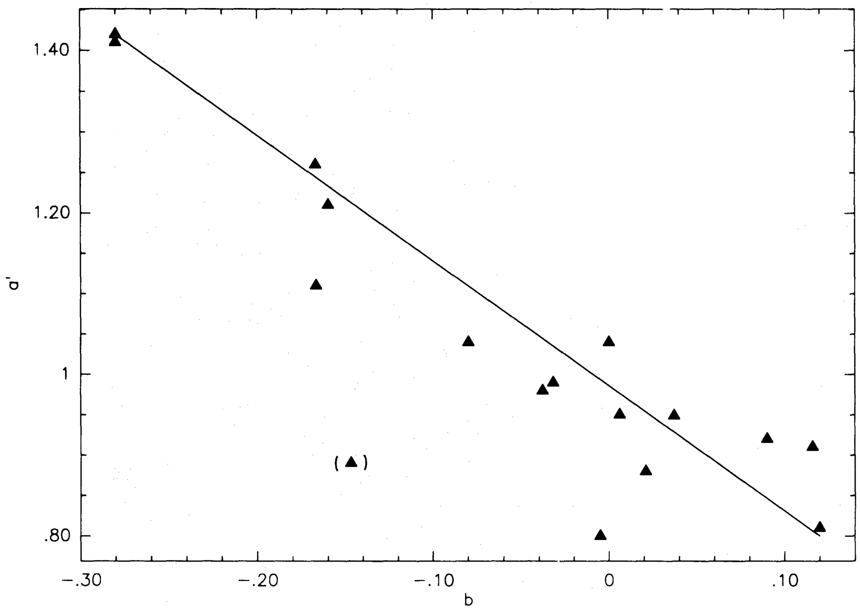

Fig. 7. Relationship between the coefficient a' of Rel. 2 and the coefficient b of Rel. 1, assuming $a=1$ and $c=0$

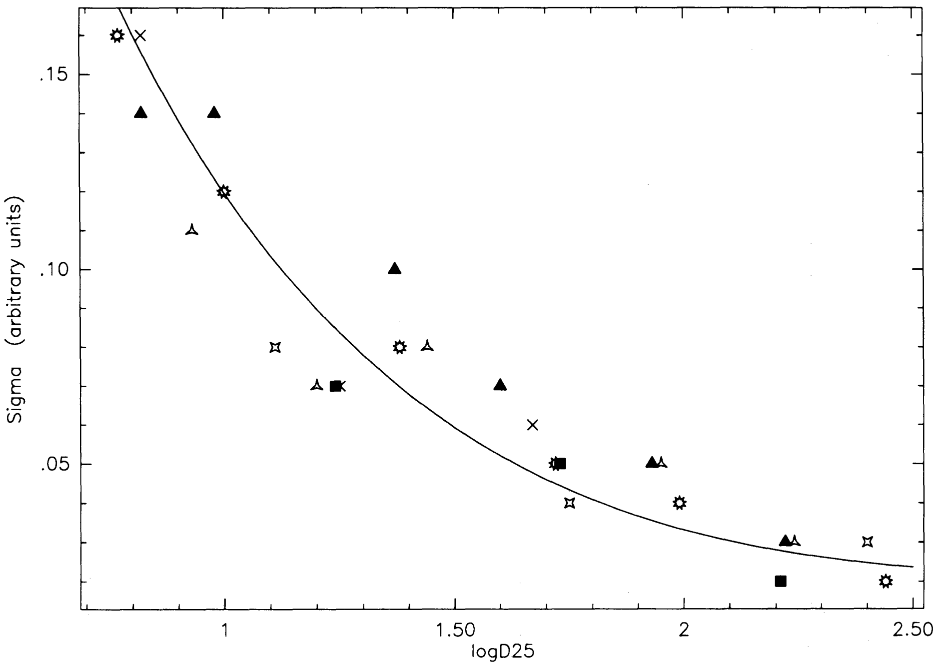

Fig. 8. The dispersion of $\sigma(\log D_{25})$ versus $\log D_{25}$ measured on $\log D - \log D$ plots for different catalogues. The curve gives the mean adopted relation assuming a mean value $K=0.1$. The symbols are the following: MCG (9-point mark), ESO (3-point mark), SGC (filled triangle), KUG (cross), KAR (4-point mark), UGCA (filled square)

Table 4. Constant K used for the calculation of the dispersion $\sigma(\log D)$

Catalogue	$T \geq 0$	$T < 0$
STD2	0.07	0.09
ESGC	0.09	0.12
MCG	0.09	0.14
ESO	0.09	0.11
SGC	0.09	0.11
KUG	0.05	
KAR-ISL	0.07	
VCC	0.09	
UGCA	0.09	
HOLMBERG	0.07	
KAZA	0.15	
TOLOLO	(0.09)	

difference $\log D_{25}(\mathrm{STD1}) - \log D^c_{25}$ (where $\log D^c_{25}$ is the diameter corrected to the standard D_{25}-system) is tested as a function of the effective mean surface brightness m'_e. Some catalogues are not significantly affected by this effect, but on the mean, there is a very small significant trend. Combining all catalogues, the net result is:

$$\log D_{25}(\mathrm{STD1}) - \log D^c_{25} = -0.013(m'_e - 12.9) \quad n=3515 \qquad (5)$$
$$\pm 0.002$$

where m'_e is in B mag arcmin^{-2}. This effect is so small that it can be neglected in practically all cases. In RC3, the mean value of m'_e is 13 B mag arcmin^{-2} while its range is 9–17 B mag arcmin^{-2}. Thus, if the mean surface brightness effect is neglected, the error in $\log D_{25}$ does not exceed 0.052, i.e. about the standard mean error. For Low Surface Brightness galaxies (LSB) with an extreme value of m'_e (say $m'_e = 17$ B mag arcmin^{-2}), Eq. 5 shows that the calculated diameter $\log D^c_{25}$ is larger than the standard one. The limiting surface brightness is thus higher in agreement with a former conclusion (Fouqué & Paturel 1985). From the value of $K_D = \delta \log D / \delta B$ (0.12 for LSB), we expect a limiting surface brightness of $25 + 0.052/0.12 = 25.43$, in fair agreement with our value (25.45 ± 0.13) found in 1985.

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