Astron. Astrophys. Suppl. Ser. **124,** 109-122 (1997)

Extragalactic database

VII. Reduction of astrophysical parameters

G. Paturel[1], H. Andernach[1] L. Bottinelli[2,3], H. Di Nella[1], N. Durand[2], R. Garnier[1], L. Gouguenheim[2,3], P. Lanoix[1], M.C. Marthinet[1], C. Petit[1], J. Rousseau[1], G. Theureau[2], and I. Vauglin[1]

[1] CRAL-Observatoire de Lyon, UMR 5574, F-69230 Saint-Genis Laval, France
[2] Observatoire de Paris-Meudon, URA 1757, F-92195 Meudon Principal Cedex, France
[3] Université Paris-Sud, F-91405 Orsay, France

Received September 10; accepted November 5, 1996

Abstract. The Lyon-Meudon Extragalactic database (LEDA) gives a free access to the main astrophysical parameters for more than 100 000 galaxies. The most common names are compiled allowing users to recover quickly any galaxy. All these measured astrophysical parameters are first reduced to a common system according to well defined reduction formulae leading to mean homogeneized parameters. Further, these parameters are also transformed into corrected parameters from widely accepted models. For instance, raw 21-cm line widths are transformed into mean standard widths after correction for instrumental effect and then into maximum velocity rotation properly corrected for inclination and non-circular velocity. This paper presents the reduction formulae for each parameter: coordinates, morphological type and luminosity class, diameter and axis ratio, apparent magnitude (UBV, IR, HI) and colors, maximum velocity rotation and central velocity dispersion, radial velocity, mean surface brightness, distance modulus and absolute magnitude, and group membership. For each of these parameters intermediate quantities are given: galactic extinction, inclination, K-correction etc..

All these parameters are available from direct connexion to LEDA and distributed on a standard CD-ROM (PGC-ROM 1996) by the Observatoire de Lyon via the CNRS.

Key words: galaxies: fundamental parameters — astronomical data bases: miscellaneous — catalogs

1. Introduction

This paper gives a detailed description of the reduction of astrophysical parameters available through LEDA database for more than 100 000 galaxies. It is often required by users of LEDA who need a reference where the description of parameters reduction is given. Most of these reduction procedures were described in previous studies:

– Central velocity dispersion (Davoust et al. 1985)
– Kinematical distance modulus (Bottinelli et al. 1986)
– HI data (HI velocity, flux and 21-cm line width) (Bottinelli et al. 1990)
– Diameters (Paturel et al. 1991)
– Names of galaxies (Paturel et al. 1991a)
– Group membership (Garcia 1993)
– Apparent magnitudes (Paturel et al. 1994)
– Correction for inclination effect (Bottinelli et al. 1995).

Here, we will summarize these reduction and give reductions for some additional parameters: morphological types and mean effective surface brightness.

Each forthcoming section will be devoted to a given class of parameter.

2. General features

In the following sections, each parameter will be designated in a unique way by the word used in the LEDA query language. The correspondence between this designation and the meaning is given in Appendix B together with the variable name used in programs and the format (FORTRAN convention). Such a designation aims at avoiding subscript or exponant characters which can not be used in simple text printing or keyboard entering.

The error on each parameter is now calculated using a method which gives better description of the actual accuracy of the measurement. In previous catalogs the standard error on an average parameter was simply calculated from the sum of weights of each individual parameter (the weight being the inverse square of individual standard error). Now, the standard error is augmented quadratically,

Send offprint requests to: G. Paturel

by the external standard deviation between each parameter. This estimate will be designated as the *actual uncertainty.* The precise expression is explained in Appendix A. The main advantage of this new definition is that a parameter with low actual uncertainty cannot result from discrepant individual measurements. So, this definition allows the user to select undoubtly good data.

All parameters are available through LEDA[1] or from a CD-ROM distributed by the Observatoire de Lyon via the CNRS.

3. Name of galaxies

We collected the most common names among 40. The different acronyms used are listed in Table 1 with their abbreviation and the number of occurrences. Some names designate several objects (e.g. UGC1 designates two galaxies, PGC 00177 and PGC 00178). In such cases the name is given to both objects between parentheses.

Since our first catalog of Principal Galaxies (PGC Paturel et al. 1989, 1989a) we have added many new galaxies in LEDA database. Each galaxy created in LEDA database receives a permanent LEDA number. (with the acronym LEDA). Note that LEDA number is identical to PGC number for running number less than 73198. PGC numbers are sorted according to right ascension and declination for epoch 2000.

Many galaxies are known by their lexical name. These names are useful for some nearby large galaxies (Dwingeloo 1 and 2; Maffei 1 and 2 etc...). The equivalence of these names is given in Table 2.

4. Coordinates

Equatorial coordinates (Right ascension and Declination) are given for two equinoxes 1950 (Besselian coordinates $al1950$, $de1950$) and 2000 (Julian coordinates $al2000$, $de2000$). Most of published coordinates are B1950 coordinates. Conversion to J2000 has been made according to the "Merits Standards" published in the U.S. Naval Observatory Circular (1983). For computer use, coordinates are expressed as decimal values (hours to 0.00001 and degrees to 0.0001 for Right Ascension and Declination, respectively). The standard deviation of coordinates is generally not known. Thus we are using a flag *ipad* to tell if the standard deviation is smaller than 10 arcsec or not. We collected systematically accurate coordinates in literature (see Paturel et al. 1989). Recently, we added accurate coordinates directly obtained from images stored in LEDA (Paturel et al. 1996) and from COSMOS database (Rousseau et al. 1996). Among the 100872 galaxies 69165 have accurate coordinates (69 percent).

[1] **telnet** lmc.univ-lyon1.fr – **login: leda**
or: http://www-obs.univ-lyon1.fr/base/home_base.fr.html

Table 1. List of acronyms

Acronym	N	Reference
PGC	101258	Paturel et al. 1989
MCG	30662	Vorontsov-Velyaminov et al. 1962-1974,
CGCG	29825	Zwicky et al. 1961-1968
ESO	17277	Lauberts 1982
UGC	13084	Nilson 1973
IRAS	11565	IRAS, Point Source Catalogue, 1988
KUG	7942	Takase & Miyauchi-Isobe 1984-1993
SAIT	7044	Saito et al. 1990
NGC	6517	Dreyer 1888
DRCG	5725	Dressler 1980
IC	3509	Dreyer 1895, 1910
FGC	2573	Karachentsev et al. 1993
VCC	2097	Binggeli et al. 1985
FGCE	1881	Karachentsev et al. 1993
MARK	1514	Markaryan et al. 1967-1981
KCPG	1206	Karachentsev 1987
ANON	1179	de Vaucouleurs et al. 1976
FAIR	1185	Fairall 1977-1988
VV	1164	Vorontsov-Velyaminov 1977
nZW	2714	Zwicky 1971
KARA	1051	Karachentseva 1973
UM	652	Kojoian et al. 1982
VIIIZW	645	Zwicky et al. 1975
ARAK	595	Kojoian et al. 1981
KAZA	581	Kazarian 1979-1983
DCL	570	Dickens et al. 1986
ARP	561	Arp 1966
HICK	464	Hickson 1993
UGCA	441	Nilson 1974
FCC	340	Ferguson & Sandage 1990
FGCA	291	Karachentsev et al. 1993
SBS	284	Markarian 1983-1984
DDO	242	Fisher & Tully 1975
WEIN	207	Weinberger 1980
TOLO	111	Smith et al. 1976
RB	57	Rood & Baum 1967
nSZW	58	Rodgers et al. 1978
MESS	40	Messier 1781
POX	24	Kunth et al. 1981

Galactic coordinates $l2$, $b2$ are calculated (in degrees to 0.01 deg) from $al1950$ and $de1950$ using the coordinates of the galactic pole $al1950(\text{pole}) = 12.81667$ $de1950(\text{pole}) = 27.4000$ and the coordinates of the origin $al1950(\text{origin}) = 17.70667$ $de1950$ $(\text{origin}) = -28.9167$ according to Blaauw et al. (1960). These galactic coordinates are used to estimate the galactic extinction ag converted to Burstein-Heiles system (Burstein & Heiles 1984) from the relationship given in the Second Reference Catalog (de Vaucouleurs et al. 1976; p32, rel. 22; hereafter RC2). In fact, for galactic latitude $b2 \geq 20\,\text{deg}$ the difference between both systems is negligibly small (except for the zero point difference of 0.20 mag due to the fact that

Table 2. Galaxies known by their lexical name

Lexical name	Usual name	PGC number
LMC	ESO 56-115	PGC 0017223
SMC	NGC 292	PGC 0003085
Maffei1	UGCA 34	PGC 0009892
Maffei2	UGCA 39	PGC 0010217
Circinus	ESO 97- 13	PGC 0050779
SextansA	MCG -1-26- 30	PGC 0029653
SextansB	UGC 5373	PGC 0028913
Carina	ESO 206- 20A	PGC 0019441
Draco	UGC 10822	PGC 0060095
Fornax	ESO 356- 4	PGC 0010093
Sculptor	ESO 351- 30	PGC 0003589
UrsaMinor	UGC 9749	PGC 0054074
Phoenix	ESO 245- 7	PGC 0006830
LeoA	UGC 5364	PGC 0028868
Pegasus	UGC 12613	PGC 0071538
WLM	MCG -3- 1- 15	PGC 0000143
Malin1		PGC 0042102
HydraA	MCG -2-24- 7	PGC 0026269
CygnusA	MCG 7-41- 3	PGC 0063932
HerculesA	MCG 1-43- 6	PGC 0059117
Dwingeloo1		LEDA0100170
Dwingeloo2		LEDA0101304

Burstein-Heiles give no absorption at the galactic pole). In Fig. 1 the difference between ag from RC2 and from Burstein-Heiles is plotted vs. the galactic latitude.

The conversion from RC2- to BH-system is the following: if $|b2| < 20\,\mathrm{deg}$:

$$ag(BH) = ag(RC2) + 0.70 - 0.045\ |b2| \quad (1)$$

and if $|b2| \geq 20\,\mathrm{deg}$:

$$ag(BH) = ag(RC2) + 0.001\ |b2| - 0.22. \quad (2)$$

The galactic extinction is higher than the one predicted by RC2 formula for low galactic latitude ($b2 < 20\,\mathrm{deg}$). The adopted galactic extinction is $ag = ag(BH) + 0.20$, where $ag(BH)$ is calculated from Rel. 1 and Rel. 2.

Supergalactic coordinates sgl, sgb are calculated (in degrees to 0.01 deg) from $l2$, $b2$ using the coordinates of the supergalactic pole $l2(\mathrm{pole}) = 47.37$ deg $b2(\mathrm{pole}) = 6.32$ deg and the coordinates of the origin $l2(\mathrm{origin}) = 137.37$ deg; $b2(\mathrm{origin}) = 0$ deg according to de Vaucouleurs et al. (1976).

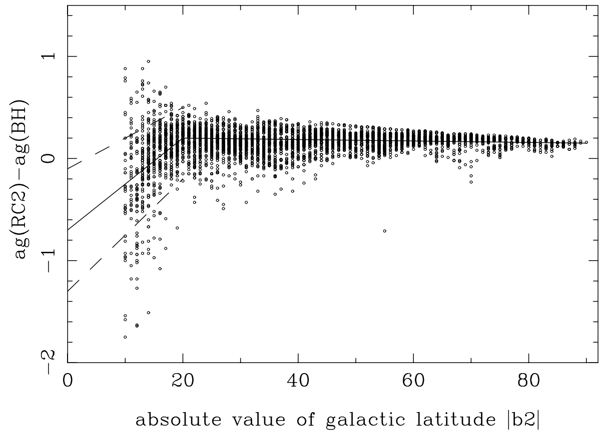

Fig. 1. Difference of galactic extinction from RC2 and Burstein-Heiles vs. the absolute value of the galactic latitude

5. Morphological type, luminosity class, and luminosity index

Morphological types (E, SO, Sa ... Sm, Irr) have been entered in LEDA as an internal numerical code. This code will be treated as a continuous quantity.

Obviously, the definition of what is a given morphological type is not the same for each astronomer. We thus adopted the RC3 type code system as a reference one and converted to it all type codes of others catalogs. A rms dispersion can be attached to each type code for each reference allowing us to calculate a weighted mean morphological type code t and its actual uncertainty st. In addition, some features have been coded in LEDA: ring, bar, interaction (or multiplicity), and compactness. These features are simply given as a flag R, B, M for the first three parameters and C or D for the last one (C for compact and D for diffuse). Further, the numerical code t and the features above are used to produce a literal Hubble type *typ* (e.g. SBa). The ranges of definition are in Table 4.

Table 3. Output morphological type codes

range of t	*typ*	range of *typ*	type
$-5 \leq t < -3.5$	E	$3.5 \leq t < 4.5$	Sbc
$-3.5 \leq t < -2.5$	E-SO	$4.5 \leq t < 6.5$	Sc
$-2.5 \leq t < -1.5$	SO	$6.5 \leq t < 7.5$	Scd
$-1.5 \leq t < 0.5$	SOa	$7.5 \leq t < 8.5$	Sd
$0.5 \leq t < 1.5$	Sa	$8.5 \leq t < 9.5$	Sm
$1.5 \leq t < 2.5$	Sab	$9.5 \leq t < 10$	Irr
$2.5 \leq t < 3.5$	Sb		

When the morphological type is uncertain ($st \geq 4.$) a rough type is used with a question mark (e.g. E? or S?).

The histogram of mean morphological type codes is given in Fig. 2. These type codes are available for 60130 galaxies.

The luminosity class introduced by Van den Bergh (1960) has been numerically coded between 1 and 9 with

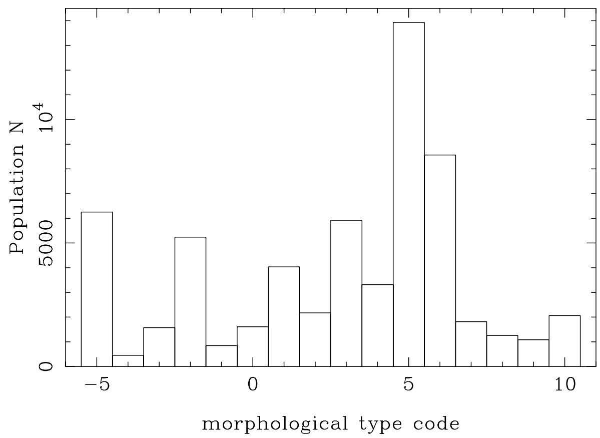

Fig. 2. Histogram for morphological type codes

the extension introduced by H.G. Corwin (SGC, 1985) between 9 and 11. The codes are given in Table 5.

Table 4. Luminosity class codes

code	original class	code	original class
1	I	7	IV
2	I-II	8	IV-V
3	II	9	V
4	II-III	10	V-VI
5	III	11	VI
6	III-IV		

This code is treated as a continuous parameter. We calculated the mean luminosity class *lc* and the actual uncertainty *slc* by giving the same weight to each reference.

Luminosity class codes and morphological type codes are used to calculate the luminosity index *lambda* according to de Vaucouleurs et al. (1979).

$$lambda = (lcc + t)/10 \quad (3)$$

where *lcc* is the luminosity class corrected for inclination according to the relation:

$$lcc = cl - c.\log r25 \quad (4)$$

where $\log r25$ is the axis ratio defined in Sect. 6 and c is a parameter depending on the morphological type code t ($c = 2.0$ for $t \leq 5$ and $c = 2.0 - 0.9(t - 5)$, otherwise).

6. Diameter and axis ratio

Many papers were devoted to the study of diameters and specially to the reduction to the standard system defined by the isophote at the brightness of $25B$-mag arcsec^{-2}. The conclusion of these studies was published by Paturel et al. (1991).

The diameters are expressed to $0.01'$ in log of $0.1'$ according to the convention of Second Reference Catalog (de Vaucouleurs et al. 1976). They are designated as $\log d25$. For instance a diameter of $10'$ will be given as $\log d25 = 2.00$. Axis ratios are expressed in log of the ratio of the major axis to the minor axis. They are designated as $\log r25$.

The main catalogs are reduced to the D_{25}-standard system using a relationship

$$logd25 = a.\log D + b \quad (5)$$

$$logr25 = a'.\log R \quad (6)$$

where D is the diameter and R is the ratio of the major axis to the minor axis in a given catalog. The constants a, b and a' are given in Paturel et al. (1991, Tables 1a and 1b) for the most common catalogs. Diameters and axis ratios extracted from LEDA images or from COSMOS database were converted into the standard system using the same relationships but with different coefficients (Paturel et al. 1996; Garnier et al. 1996; Rousseau et al. 1996).

The completeness curve $\log N$ vs. the limiting $\log d25$ is shown in Fig. 3. The completeness is satisfied down to the limit $\log d_l = 0.9$ (i.e. $0.8'$ in diameter). Diameters $\log d25$ are available for 82033 galaxies. The histogram of actual uncertainty $s\log d25$ on apparent diameter $\log d25$ is given in Fig. 4. More than 13 000 galaxies have a diameter with an actual uncertainty smaller than 0.05 (in $\log d25$). The distribution of logarithms of axis ratios is shown in Fig. 5. This distribution is close to the one expected if the orientation of galaxies is randomly distributed.

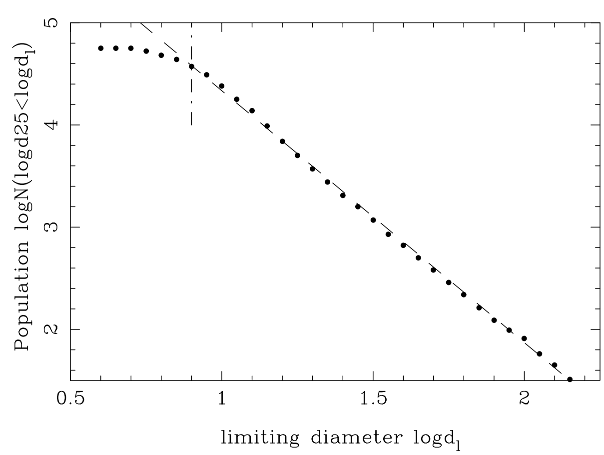

Fig. 3. Completeness curve for $\log d25$. The completeness is satisfied down to the limit $\log d_l = 0.9$ (i.e. $0.8'$ in diameter)

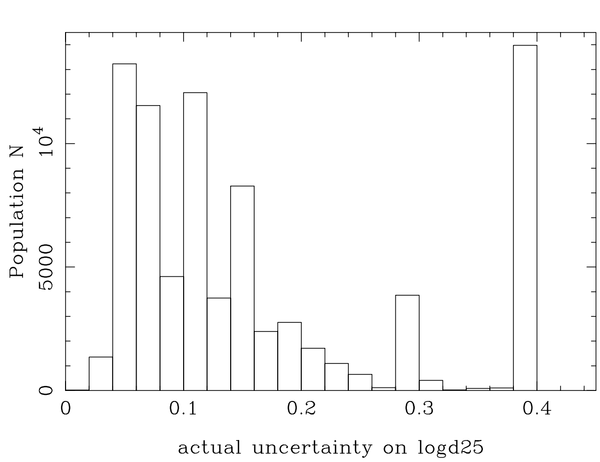

Fig. 4. Histogram of actual uncertainty slog$d$25 on apparent diameter log$d$25

The position angle of the major axis is noted PA. It is counted from North towards East, between 0 deg and 180 deg and is almost randomly distributed (Fig. 6). A small excess of galaxies appears at PA = 90 deg and PA = 180 deg which seems to be an artifact.

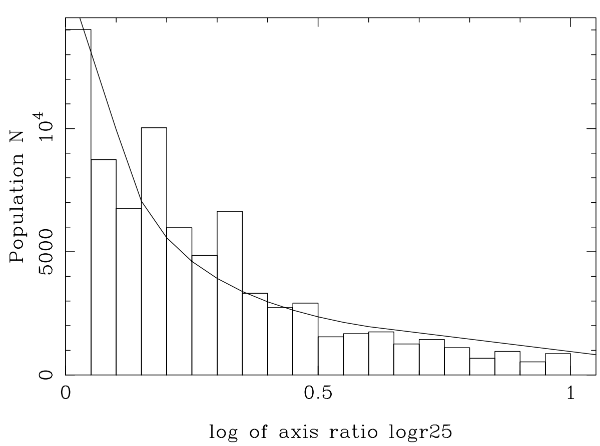

Fig. 5. Histogram of log of axis ratio log$r$25. The solid curve shows the distribution of log$r$25 for random orientation

In RC2 apparent diameters were corrected for galactic extinction and inclination effect according to Heidmann & de Vaucouleurs (1972a,b,c). Recently, this question was revisited after the result by Valentijn (1990, 1994) that galaxy disks are opaque. Our conclusion (Bottinelli et al. 1995) leads to the following correction:

$$\log dc = \log d25 - C.\log r25 + ag.K_{\rm D} \quad (7)$$

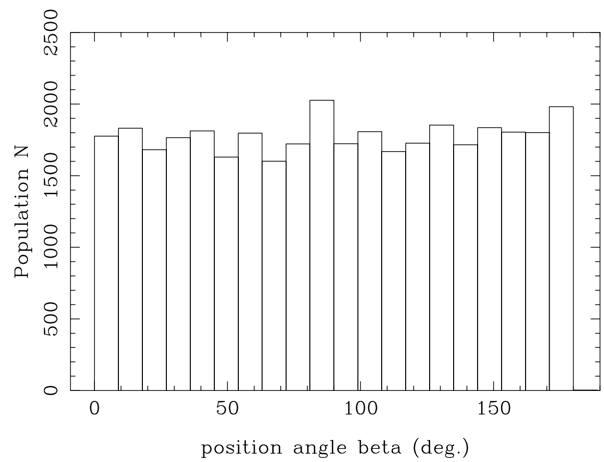

Fig. 6. Distribution of major axis position angles

where $C = 0.04$, ag is the galactic extinction (see section about coordinates) and $K_{\rm D}$ is given by Fouqué & Paturel (1985) as 0.094 for spiral galaxies and $0.081 - 0.016.t$ for early type galaxies with morphological type code $t < 0$.

7. Apparent magnitude and colors

The reduction of apparent B-magnitude to the RC3-system of magnitudes $B_{\rm T}$ with photoelectric zero-point has been studied recently (Paturel et al. 1994). Apparent B-magnitudes reduced to the RC3-system will be designated as bt. Several effects were taken into account. The reduction of a given magnitude m to bt is given by:

$$\begin{aligned} bt = {} & a.m + b + \\ & c.(\log r25 - < \log r25 >) + d.(t - < t >) + \\ & e.(\log d25 - < \log d25 >) + f.(de1950 - < de1950 >) \end{aligned} \quad (8)$$

where a, b, c, d, e, f, $< \log r25 >$, $< t >$, $< \log d25 >$, $< de1950 >$ are constant values given in Paturel et al. (1994, Table 6). The mean bt magnitude is calculated as a weighted mean where the weight is derived for each source of magnitude as the inverse square of the mean standard deviation. The final actual uncertainty sbt is derived from the total weight.

The cumulative completeness curve $logN$ vs. bt is shown in Fig. 7. The completeness in apparent magnitude is satisfied up to $bt = 15.5$. Apparent total magnitude bt is available for 76760 galaxies. The histogram of actual uncertainties sbt on bt is given in Fig. 8. More than 7 000 galaxies have an actual uncertainty on bt smaller than 0.02 mag.

Note that apparent diameter can be roughly converted into a magnitude m assuming that the mean surface brightness is constant for all galaxies. The conversion can be made using the relationship (Di Nella & Paturel 1994):

$$m = 20.0 - 5.\log d25. \quad (9)$$

The standard deviation on m is about 0.5 mag. Using this relation, it is possible to obtain an estimate of the apparent magnitude for 93062 galaxies, 76760 magnitudes of which come from bt and 16302 from log$d$25. This magnitude m will be used for drawing a more general completeness curve (Fig. 11).

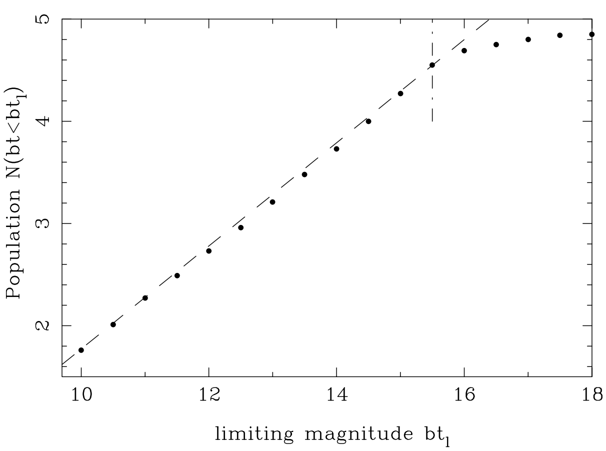

Fig. 7. Completeness curve for apparent magnitude bt. The completeness is satisfied up to the limit $bt = 15.5$

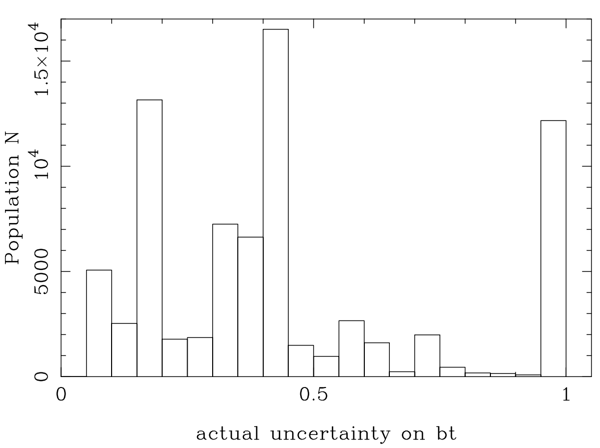

Fig. 8. Histogram of actual uncertainty on apparent magnitudes bt

Apparent bt magnitudes are corrected for galactic extinction, inclination and redshift effects according to the relation:

$$btc = bt - ag - ai - ak.v/10000 \quad (10)$$

where ag is the galactic extinction in B (see Sect. 4), expressed in magnitude, ak is taken from de Vaucouleurs et al. (1976, RC2 p33, rel.25), v is the heliocentric velocity in km s^{-1} (Sect. 9) and ai is given by Bottinelli et al. (1995) as:

$$ai = 2.5\log(k + (1 - k).R^{2C(1+0.2/K_{\rm D})-1}) \quad (11)$$

where, $k = l_{\rm Bulge}/l_{\rm Total}$ is taken from Simien & de Vaucouleurs (1986), as a function of the morphological type code. $K_{\rm D}$ is taken from Fouqué & Paturel (1985) as seen before (Sect. 6), $C = 0.04$ (Bottinelli et al. 1995) and $R = 10^{\rm alr25}$. Note that this relation has been demonstrated for spiral galaxies only. For early type galaxies ($t < 0$) we assume $ai = 0$, in agreement with de Vaucouleurs et al. (1991).

Colors are given in the UBV system[2]. They are: total asymptotic colors ubt for $(U - B)_{\rm T}$; bvt for $(B - V)_{\rm T}$ and effective colors (i.e. colors within the effective aperture in which half the total B-flux is emitted) ube for $(U - B)_{\rm e}$; bve for $(B - V)_{\rm e}$. Total asymptotic colors are corrected for galactic extinction, inclination and redshift effects according to RC3. The corrected colors are $bvtc$ and $ubtc$ for $(B - V)_{\rm T}$ and $(U - B)_{\rm T}$ respectively.

8. Maximum velocity rotation and central velocity dispersion

We published compilations of HI-data in 1982 and 1990 (Bottinelli et al. 1982; Bottinelli et al. 1990) but the data are regularly updated from literature. The reduction of raw measurements is the same. The 21-cm line widths are reduced to two standard levels (20% and 50% of the peak) and to zero-velocity resolution using the following formula:

$$ws(l; r = 0) = w(l', r) + (a.l' + b)r + c(l - l') \quad (12)$$

where $ws(l, r = 0)$ is the standard 21-cm line width at level $l = 20$ or $l = 50$, while $w(l', r)$ is a raw measurement at a level l' made with a velocity resolution of r km s^{-1}. The constants a, b and c are (Bottinelli et al. 1990): $a = 0.014, b = -0.83, c = -0.56$.

The resulting standard 21-cm line widths $ws(l = 20, r = 0)$ and $ws(l = 50, r = 0)$ are corrected for systematic errors by intercomparison reference by reference (program INTERCOMP, Bottinelli et al. 1982) leading to standard widths $w20$ and $w50$ and their actual uncertainties $sw20$ and $sw50$ respectively.

[2] some additional colors $V - R$, $R - I$ are listed in LEDA but they do not represent a significant enough sample to be included in the present version of the mean parameters.

$w20$ and $w50$ are used to calculate the log of the maximum velocity rotation following the expression.

$$\log vm = <\log(wc)> - \log(2\sin(\mathrm{incl})) \quad (13)$$

where incl is the inclination (in degrees) between the polar axis and the line of sight calculated from the classical formula (Hubble 1926):

$$\sin^2(\mathrm{incl}) = \frac{1-10^{-2.\log r25}}{1-10^{-2.\log ro}} \quad (14)$$

where $\log ro = 0.43 + 0.053.t$, if $-5 \le t \le 7$ (or $\log ro = 0.38$ if $t > 7$), has been obtained from the most flattened galaxies.

$<\log(wc)>$ is the weighted mean of the logarithm of the line widths $w20$ and $w50$ corrected for internal velocity dispersion. The adopted weight of level 20% is twice the weight of level 50% because it is less sensitive to the definition of the maximum and also because it corresponds to larger fraction of the disk. The correction for internal velocity dispersion is taken according to Tully & Fouqué (1985).

$$wc^2 = w^2 + wt^2(1-2\mathrm{e}^{-w^2/wr^2}) - 2w.wt(1-\mathrm{e}^{-w^2/wr^2}) \quad (15)$$

where w is either $w20$ or $w50$ and $wt = 2\sigma_z.k(l)$, assuming an isotropic distribution of the non-circular motions $\sigma_z = 12$ km s^{-1} and a nearly Gaussian velocity distribution (i.e. $k(20) = 1.96$ and $k(50) = 1.13$).

Mean maximum velocity rotation logvm is available for 6415 galaxies, from 34 436 individual measurements $w20$ or $w50$.

The actual uncertainty on logvm can be approximated by (For the detailed calculation see Bottinelli et al. 1983):

$$s\log vm = 0.2\,\frac{sw^2}{w^2} + \frac{s\log r25^2}{(10^{2\log r25}-1)^2} \quad (16)$$

where sw and w are used for ($sw20$ or $sw50$) and ($w20$ or $w50$), respectively. The histogram of $s\log vm$ is presented in Fig. 9.

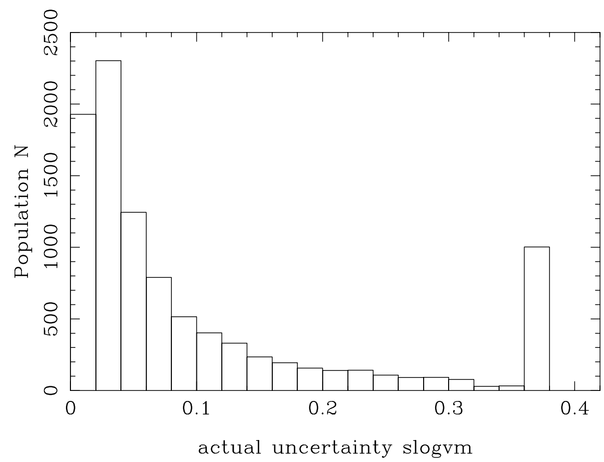

Fig. 9. Histogram of the actual uncertainty on maximum velocity rotation logvm

A preliminary compilation of central velocity dispersions log$s$ was published in 1985 (Davoust et al. 1985) and included in our database. This compilation has been regularly updated from literature (including compilations made by Whitmore et al. 1985; McElroy 1995; Prugniel & Simien 1995). Measurements from various references have been homogeneized using the INTERCOMP program (Bottinelli et al. 1982). The mean central velocity dispersion log$s$ is available for 1816 galaxies resulting from 3402 individual measurements. The actual uncertainty slog$s$ in log scale is shown in Fig. 10.

In Fig. 11 we present the completeness of kinematical parameters logvm or log$s$ in comparison with the total completeness curve. The completeness is fulfilled up to about $m = 12.0$ mag.

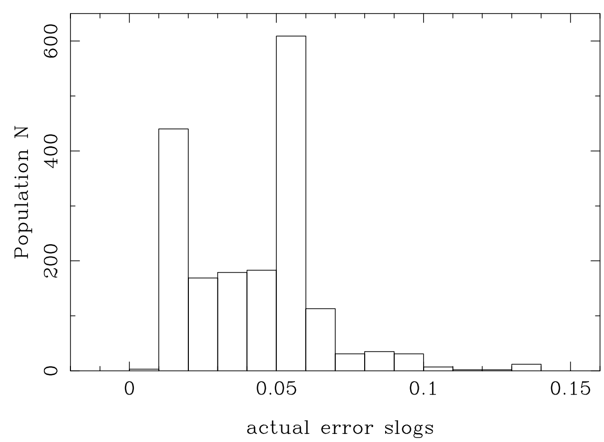

Fig. 10. Histogram of the actual uncertainty on central velocity dispersion log$s$

9. Radial velocities

Heliocentric radial velocities are obtained from optical or radio measurements $v$opt or $v$rad, respectively. The original optical compilation was made for the preparation of the RC3 catalog (Fouqué et al. 1992). Velocities are corrected for systematic errors from the intercomparison reference by reference. The weight is deduced for each reference from this comparison. This allows the calculation of the actual uncertainty svopt. Radio velocities come essentially from 21-cm line measurements (plus some additional CO measurements). The agreement between different authors is generally excellent and there is no need of systematic correction. Mean error $svrad$ is given as a function of the velocity resolution (Bottinelli et al. 1990).

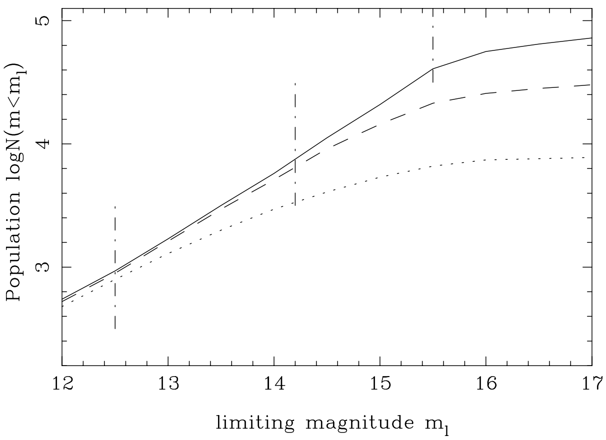

Fig. 11. Completeness curve for m. The completeness is satisfied up to the limit $m_l = 15.5$ (solid line). This limit drop to $m \approx 14.2$ if we impose that the radial velocity is known (dashed line), and to $m = 12.0$ if we impose that either the maximum velocity rotation or the central velocity dispersion is known (dotted line)

From both $v$opt and $v$rad we calculate a weighted mean heliocentric velocity v, the weights being the inverse squares of *svopt* and *svrad* respectively. The final weight leads to the actual uncertainty sv. When the discrepancy between $v$opt and $v$rad is larger than 1000 km s^{-1}, we do not calculate the mean heliocentric velocity v but adopt instead the velocity having higher weight. Radial velocity v is available for 39667 galaxies.

From this mean heliocentric velocity v we obtain four velocities defined with different reference frames. The velocity corrected to the galactic center *vgsr* is obtained by a correction of the motion of the Sun with respect to the local standard of rest (LSR) and a correction of the LSR motion with respect to the galactic center. The resulting correction is:

$$vgsr = v + 232.\sin(al2)\cos(ab2) + 9.\cos(al2)\cos(ab2) + 7\sin(ab2). \quad (17)$$

The velocity corrected to the centroid of the Local Group *vlg* has been adopted following Yahil et al. (1977):

$$vlg = v + 295.4\sin(al2)\cos(ab2) - 79.1\cos(al2)\cos(ab2) - 37.6\sin(ab2). \quad (18)$$

This correction replaces the classical IAU correction $300\sin(al2)\cos(al2)$.

The velocity corrected for infall of the Local Group towards Virgo is noted *vvir*. It is calculated as:

$$vvir = vlg + 170.\cos(\theta) \quad (19)$$

where 170 km s^{-1} is the infall velocity of the Local Group according to Sandage & Tammann (1990) and where θ is the angular distance between the observed direction *sgl*, *sgb* in supergalactic coordinates and the direction of the center of the Virgo cluster ($sglo = 104$ deg, $sgbo = -2$ deg).

$$\cos(\theta) = \sin(sgbo)\sin(sgb) + \cos(sgbo)\cos(sgb)\cos(sglo - sgl). \quad (20)$$

Finally, the radial velocity is also expressed in the reference frame of the Cosmic Background Radiation. This velocity is noted $v3k$. It is calculated from the heliocentric velocity v using the total solar motion of 360 km s^{-1} towards the direction defined by the 1950- equatorial coordinates $al3k = 11.25h$ $de3k = -5.6$ deg (Lubin & Villela 1986). In 1997 this calculation should be replaced by the new determination from COBE (Bennett et al. 1996). However, according to the rule defined at the end of the present paper (see the section "acknowledgements"), the old definition will be used until the end of 1996:

$$v3k = v + 360.\cos(\theta 3k) \quad (21)$$

with $\theta 3k$ given by:

$$\cos(\theta 3k) = \sin(de3k)\sin(de1950) + \cos(de3k)\cos(de1950)\cos(al3k - al1950). \quad (22)$$

10. HI-line and IR fluxes

HI line flux (flux corresponding to the area under the 21-cm line profile) and IRAS fluxes are treated separately from the classical magnitudes (UBV) because they are obtained and corrected in a completely different way.

The HI line flux is generally expressed in Jy km s^{-1} converted in magnitude $m21$ according to the formula adopted in RC3:

$$m21 = -2.5\log(f) + 17.40 \quad (23)$$

where f is the area of the 21-cm line profile expressed in Jansky km s^{-1}. This formula is equivalent to the one used in RC3: $m21 = -2.5\log(fwm) + 16.6$, where fwm is the flux in 10^{-22} W m^{-2}. The standard error $sm21$ on $m21$ is given as a function of the radiotelescope according to Bottinelli et al. (1990).

The HI line magnitude $m21$ has been corrected for self-absorption effect following Heidmann et al. (1972):

$$m21c = m21 - 2.5\log\frac{\kappa/\cos(\mathrm{incl})}{(1 - \exp(\kappa/\cos(\mathrm{incl})))}. \quad (24)$$

The adopted free parameter is $\kappa = 0.031$. If inclination is higher than 89 deg the maximum correction is limited to -0.82 mag.

Both magnitudes $m21c$ and btc are used to calculate a HI color index hi initially defined by de Vaucouleurs et al. (1976):

$$hi = m21c - btc. \quad (25)$$

This parameter is interesting as it is directly connected to the hydrogen contents per unit of B-flux (see RC3, p51 Rel. 78). The relation between hi and morphological type code t is presented in Fig. 12. It shows a clear correlation which validates the use of morphological type code as an observable parameter.

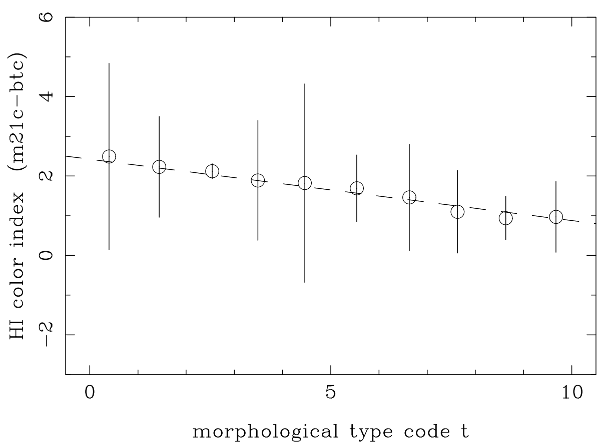

Fig. 12. Mean HI color index hi vs. morphological type code t

IRAS fluxes at 60 μm and 100 μm are converted in the so-called far-infrared flux according to the relation:

$$mfir = -2.5\log(2.58.f60 + f100) + 14.75 \quad (26)$$

where $f60$ and $f100$ are IRAS fluxes at 60 μm and 100 μm expressed in Jansky. This relation is equivalent to the relation given in RC3. The term 14.75 comes from the arbitrary zero-point of 20 in RC3 (p.43, Rel. 49). The factor 2.58 comes from IRAS *Point Source Catalog* (1988).

11. Mean surface brightness

The parameter $brief$ (with its actual uncertainty $sbrief$) is the mean effective surface brightness, i.e. the mean surface brightness inside the effective aperture (the circular aperture enclosing one-half the total flux). This mean surface brightness is expressed in B-mag arcsec.$^{-2}$.

Two equivalent measurements of brief were derived: i) from the apparent diameter D_n enclosing a mean surface brightness of 20.75 $B-$mag arcsec.$^{-2}$ (Dressler et al. 1987), ii) from the mean surface brightness inside the effective isophote (elliptical isophote enclosing one-half the total flux) measured by Lauberts & Valentijn (1989; LV).

$$\begin{aligned} \text{brief} &= -(1.87 \pm 0.07)m'(D_n) + (60.13 \pm 1.36) \\ \sigma &= 0.49 \\ \rho &= 0.74 \pm 0.02 \\ n &= 392 \end{aligned} \quad (27)$$

where $m'(D_n) = bt + 5\log(D_n) + 4.38$, σ is the standard deviation, ρ is the correlation coefficient and n the number of galaxies used for the comparison.

Similarly we have:

$$\begin{aligned} \text{brief} &= (1.14 \pm 0.02)m'(LV) + (3.05 \pm 0.46) + \\ &\qquad (1.2 \pm 0.1)\log r25^2 \\ \sigma &= 0.49 \\ \rho &= 0.84 \pm 0.01 \\ n &= 847 \end{aligned} \quad (28)$$

where m'(LV) is the *average blue central surface brightness within half total Blight* (noted $\mu_{\mathrm{e(LV)}}$ in LV) , from Lauberts & Valentijn (1989). The correction for inclination is in good agreement with the predicted one 1.35 ~ 1.26 (see RC3 p50, Rel.71). The final value $brief$ is calculated as the weighted mean of each determination.

Another estimate of the mean surface brightness is $bri25$, the mean surface brightness inside the isophote 25 $B-$ mag arcsec.$^{-2}$.

This brightness must be corrected for inclination effect (Bottinelli et al. 1995). We then obtain the corrected mean brightness $bri25$:

$$bri25 = m'25 + 2.5\log(k.R^{-2C} + (1-k)R^{(0.4C/K_{\mathrm{D}})-1}) \quad (29)$$

where

$$m'25 = bt + 5\ \log d25 + 3.63. \quad (30)$$

Notations are those used for the calculation of ai (Sect. 7).

12. Distance modulus and absolute magnitude

The kinematical distance modulus $mucin$ can be derived from the heliocentric velocity properly corrected for the Local Group infall onto the Virgo cluster $vvir$ assuming a given Hubble constant $H_0 = 75$ km s^{-1} Mpc^{-1}. It must be noted that this distance does not include a correction for the infall of individual galaxies onto Virgo. Such a distance could have been calculated for instance using the model by Peebles (1976) as described in Bottinelli et al.

(1986). However, this model does not allow the calculation in the direction of the Virgo center because of the third degree equation (Eq. (2) in Bottinelli et al. 1986). Further, this model requires the choice of a Virgo distance, of a Virgo mean radial velocity and of a velocity infall for the Local Group, while the calculation of *mucin* requires only the choice of the velocity infall for the Local Group (we adopted $V_{\rm infall} = 170$ km s^{-1} ; see Sect. 9). In the direction of Virgo cluster center *mucin* can be overestimated or underestimated depending on the background or foreground position of the considered galaxy with respect to Virgo center.

$$mucin = 5.\log(vvir/75) + 25 \qquad (31)$$

mucin is calculated only where $vvir > 500$ km s^{-1}, *mucin* is available for 39243 galaxies. It is used to derive an estimate of the absolute magnitude *amabs* in Blue band:

$$mabs = btc - mucin. \qquad (32)$$

13. Group membership

The extragalactic database was used by Garcia (Garcia et al. 1993; Garcia 1993) for a general study of group membership of all galaxies with a radial velocity less or equal to 5500 km s^{-1} and an apparent magnitude brighter than $bt = 14$. Two automatic algorithms were used simultaneously (percolation and hierarchy clustering methods) for producing very robust groups. From the whole sample 485 groups were build. They are identified by the acronym LGG (for Lyons Galaxy Group). For a galaxy, the LGG number *lgg* gives the group to which the galaxy belongs. The *lgg* number is available for 2702 galaxies.

Acknowledgements. We are grateful to those who contributed to LEDA extragalactic database: Becker M., Bravo H., Buta R.J., Corwin H.G., Davoust E., de Vaucouleurs A., de Vaucouleurs G., Fouqué P., Garcia A.M., Kogoshvili N., Hallet N., Mamon G., Miyauchi-Isobe N., Odewahn S., Prugniel Ph., Simien F., Takase B., Turatto M. and many other people who send some useful comments.

We want also to express our gratitude to some Institutions for their financial support: The "Ministère de l'Enseignement Supérieur et de la Recherche", The "Conseil Régional Rhone-Alpes" and the "Centre National de la Recherche Scientifique".

We would like to emphasize an important decision for the future: we will maintain the same reduction procedures for a full year (unless errors are found) in such a way users can clearly reference the data, for instance as LEDA1996. Any changes will be announced in the LEDA news. The data of previous years will be accessible on request.

Appendix A: Calculation of the actual uncertainty

Let us assume that for a given galaxy we have n measurements x_i $(i = 1, n)$ of a given parameter obtained from different references, each reference having a weight $w_i = 1/\sigma_i^2$, where σ_i is the standard error of the i-th individual measurement. The actual uncertainty is calculated as:

$$\sigma^2_{\rm a.u.} = \sigma^2_{\rm w} + \sigma^2_n. \qquad (1)$$

The first term $\sigma^2_{\rm w}$ denotes the inverse of the total weight The total weight, $S_{\rm w}$, is simply the sum of individual weights. (i.e. $S_{\rm w} = 1/\sigma^2_{\rm w} = \sum 1/\sigma^2_i$). This first term accounts for the accuracy of the reference of each individual measurement because the standard error of a given measurement is assigned globaly from e.g., the reference or the resolution etc... It is obvious that some individual measurements coming from a good reference can be affected by a local problem (e.g., multiplicity of the galaxy, star superimposed on the galaxy, bad seeing, misidentification etc...). This fact will be taken into account by the second term.

The second term in the definition of the actual error is a measure of the consistency of the different measurements building the mean measurement. It is calculated as the weighted standard deviation:

$$\sigma^2_n = S_2/S_{\rm w} - (S_1/S_{\rm w})^2 \qquad (2)$$

where: $S_2 = \sum_i w_i x_i^2$, $S_1 = \sum_i w_i x_i$, $S_{\rm w} = \sum_i w_i$.

The main advantage of the actual error is that it clearly shows any internal uncertainty and any external discrepancy.

Appendix B: LEDA's Astrophysical parameters

Parameter name	FORTRAN name	FORTRAN format	columns	definition
pgc	pgcleda	a11	1- 11	PGC or LEDA name (PGC = LEDA)
ident	ident	a16	12- 27	1st name (NGC,IC,UGC,ESO...)
ipad	ipadc	a1	28- 28	'*' for coordinates better than 10"
al1950	al1950	f10.5	29- 38	R.A. (B1950) (decimal hours)
de1950	de1950	f10.5	39- 48	DEC. (B1950) (decimal degrees)
al2000	al2000	f10.5	49- 58	R.A. (J2000) (decimal hours)
de2000	de2000	f10.5	59- 68	DEC. (J2000) (decimal degrees)
l2	al2	f10.3	69- 78	galactic longitude (degrees)
b2	ab2	f10.3	79- 88	galactic latitude (degrees)
sgl	sgl	f10.3	89- 98	supergalactic longitude (degrees)
sgb	sgb	f10.3	99-108	supergalactic latitude (degrees)
typ	typc	a5,1x	109-114	morph. type (e.g. 'E', 'Sab', 'SBa', 'S0')
morph	morphc	a4	115-118	'B' for Barred gal. (see note below)
				'R' for Ring gal.
				'M' for multiple gal.
				'C' for compact, 'D' for diffuse
t	t	f10.3	119-128	morph. type code ($-$5 to 10)
st	st	f10.3	129-138	actual uncertainty on t
lc	alc	f10.3	139-148	luminosity class (1 to 11)
slc	slc	f10.3	149-158	actual uncertainty on lc
log$d25$	alog$d25$	f10.3	159-168	log10 of isophotal diameter (d25 in 0.1$'$)
slog$d25$	slog$d25$	f10.3	169-178	actual uncertainty on log$d25$
log$r25$	alog$r25$	f10.3	179-188	log10 of the axis ratio (major/minor axis)
slog$r25$	slog$r25$	f10.3	189-198	actual uncertainty on log$r25$
pa	pa	f10.3	199-208	position angle (N->E) in degrees
brief	brief	f10.3	209-218	effective surface brightness (mag arcsec-2)
sbrief	sbrief	f10.3	219-228	actual uncertainty on brief
bt	bt	f10.3	229-238	total B-magnitude
sbt	sbt	f10.3	239-248	actual uncertainty on bt
ubt	ubt	f10.3	249-258	($U-B)_{\rm T}$
bvt	bvt	f10.3	259-268	($B-V)_{\rm T}
ube	ube	f10.3	269-278	($U-B)_{\rm e}
bve	bve	f10.3	279-288	($B-V)_{\rm e}
w20	w20	f10.3	289-298	21-cm line width at 20% of peak (in km/s)
sw20	sw20	f10.3	299-308	actual uncertainty on w20
w50	w50	f10.3	309-318	21-cm line width at 50% of peak (in km/s)
sw50	sw50	f10.3	319-328	actual uncertainty on w50
logs	alog$s$	f10.3	329-338	log of the central velocity disp.(s in km/s)
slogs	slog$s$	f10.3	339-348	actual uncertainty on logs
m21	am21	f10.3	349-358	HI-magnitude
sm21	sm21	f10.3	359-368	actual uncertainty on m_{21}
mfir	amfir	f10.3	369-378	far-infrared magnitude
vrad	vrad	f10.3	379-388	radio heliocentric radial velocity in km/s
svrad	svrad	f10.3	389-398	actual uncertainty on $v$rad
vopt	vopt	f10.3	399-408	optical heliocentric radial velocity in km/s
svopt	svopt	f10.3	409-418	actual uncertainty on $v$opt
v	v	f10.3	419-428	actual heliocentric radial velocity in km/s
sv	sv	f10.3	429-438	actual uncertainty on v

Parameter name	FORTRAN name	FORTRAN format	columns	definition
lgg	algg	f10.3	439-448	Lyon's galaxy group number
ag	ag	f10.3	449-458	galactic extinction in B-mag
ai	ai	f10.3	459-468	internal absorption (in B-mag)
incl	aincl	f10.3	469-478	inclination
a21	a21	f10.3	479-488	HI self-absorption
lambda	alambda	f10.3	489-498	luminosity-index
logdc	alogdc	f10.3	499-508	log of the corrected diameter (dc in 0.1$'$)
btc	btc	f10.3	509-518	corrected B-magnitude
ubtc	ubtc	f10.3	519-528	($U-B)_0$
bvtc	bvtc	f10.3	529-538	($B-V)_0$
bri25	bri25	f10.3	539-548	mean surf. brightness within 25 m/"
logvm	alogvm	f10.3	549-558	log of max.circ. rot. vel.
slogvm	slogvm	f10.3	559-568	actual uncertainty on logvm
m21c	am21c	f10.3	569-578	corrected HI-magnitude
hic	hic	f10.3	579-588	HI color index
vlg	vlg	f10.3	589-598	radial vel. relative to the LG
vgsr	vgsr	f10.3	599-608	radial vel. relative to the GSR
vvir	vvir	f10.3	609-618	radial vel. corrected for Virgo infall
v3k	v3k	f10.3	619-628	radial vel. relative to the CBR
mucin	amucin	f10.3	629-638	kinematical distance modulus (H = 75 km/s/Mpc)
mabs	amabs	f10.3	639-648	absolute B magnitude from mucin and mupar
identi	identi	20a16	649-968	alternate names

note: The parameter ‘‘morph" can be read as 4 parameters (4a1 format)
for Bar, Ring, Multiple and Compactness, respectively.

References

Arp H., Atlas of Peculiar Galaxies, 1966, California Institute of Technology

Bennett C.L., Banday A.J., Górski K.M., et al., 1996, ApJ 464, L1

Binggeli B., Sandage A., Tammann G.A., 1985, AJ 90, 1681

Blaauw A., Gum C.S., Pawsey J.L., Westerhout G., 1960, MNRAS 121, 123

Bottinelli L., Gouguenheim L., Paturel G., 1983, A&A 118, 4

Bottinelli L., Gouguenheim L., Paturel G., 1982, A&AS 47, 171

Bottinelli L., Gouguenheim L., Paturel G., Teerikorpi P., 1986, A&A 156, 157

Bottinelli L., Gouguenheim L., Fouqué P., Paturel G., 1990, A&AS 82, 391

Bottinelli L., Gouguenheim L., Paturel G., Teerikorpi P., 1995, A&A 296, 64

Burstein D., Heiles C., 1984, ApJS 54, 33

Corwin H.G., de Vaucouleurs A., de Vaucouleurs G., 1985, Southern Galaxy Catalogue, Univ. of Texas Astronomy Monographs No. 4, Astron. Dept., Austin

Davoust E., Paturel G., Vauglin, 1985, A&A 61, 273

Di Nella H., Paturel G., 1994, C.R. Acad. Sc. Paris, t. 319, Sér. II, 57

Dickens R.J., Currie M.J., Lucey J.R., 1986, MNRAS 220, 679

Dressler A., 1980, ApJS 42, 565

Dressler A., Lynden-Bell D., Burstein D., et al., 1987, AJ 313, 42

Dreyer J.L.E., 1888, Mem. Roy. Astr. Soc. 49, 1

Dreyer J.L.E., 1885, Mem. Roy. Astr. Soc. 51, 185, 1910, 59, 105

Fairall A.P., 1977, MNRAS 180, 391, 1979, 188, 349, 1980, 192, 389, 1981, 196, 417 1983, 203, 47, 1984, 210, 69, 1988, 233, 691

Ferguson H.C., Sandage A.R., 1990, AJ 100, 1

Fisher J.R., Tully R.B., 1975, A&A 44, 151

Fouqué P., Paturel G., 1985, A&A 150, 192

Fouqué P., Durand N., Bottinelli L., Gouguenheim L., Paturel G., 1992, Monographies de la base de données extragalactiques, No. 3 , Lyon (ISBN 2.908288.05.2)

Garcia A.M., 1993, A&AS 100, 47

Garcia A.M., Paturel G., Bottinelli L., Gouguenheim L., 1993, A&AS 98, 7

Garnier R., Paturel G., Petit C., Marthinet M.C., Rousseau J., 1996, A&AS 117, 467

Heidmann J., Heidmann N., Vaucouleurs G. de, 1972, Mem. Roy. Astr. Soc. 75, 85

Hickson P., 1993, Astro. Lett. Comm. 29, 1-207

Holmberg E., 1958, Medd. Lunds Obs. II, 136

Hubble E., 1926, ApJ 64, 321

IRAS, Science Working Group, 1988, IRAS Point Source Catalogue, Version 2 (Washington: US Govt. Printing Office)(PSC)

Karachentseva V.E., 1973, The Catalogue of isolated galaxies

Karachentsev I.D., 1987, Catalogue of pair of galaxies

Karachentsev I.D., Karachentseva V.E., Parnovsky S.L., 1993, Astron. Nachr. 314, 97

Kazarian M.A., 1979, Astrofiz. 15, 5, 1979, 15, 1980, 16, 17 1982, 18, 515, 1983, 19, 213

Kojoian G., Elliot R., Bicay M.D., Arakelian M.A., 1981, AJ 86, 820

Kojoian G., Elliot R., Bicay M.D., 1982, ApJS 50, 161

Kunth D., Sargent W.L.W., Kowal C., 1981, A&AS 44, 229

Lauberts A., 1982, The ESO/Uppsala Survey of the ESO(B) Atlas, European Southern Observatory

Lauberts A., Valentijn E.A., 1989, The Surface Photometry Catalogue of the ESO-Uppsala Galaxies, ESO, Munich (LV)

Lubin P., Villela T., 1986, in Galaxy Distances and Deviations from Universal Expansion, Madore B.F. and Tully R.B. (eds.). Dordrecht: Reidel, p. 16

Madore B.F., Freedman W.L., 1991, Pub. ASP 103, 933

Markaryan B.E., et al., 1967-1981, 1967, Astrofiz. 3, 55, 1969, 5, 443, 1969, 5, 581, 1971, 7, 511, 1972, 8, 155, 1973, 9, 487, 1974, 10, 307, 1976, 12, 389, 1976, 12, 657, 1977, 13, 225, 1977, 13, 397

Markarian B.E., Stepanian D.A. (Second Byurakan Spectral Survey) 1983, Astrofiz. 19, 639, 1984, 20, 21, 1984, 20, 513

McElroy D.B., 1995, ApJS 100, 105

Merits Standards, 1983, Circ. U.S. Naval Observatory

Messier C., 1781, Catalogue des Nébuleuses et des Amas d'Etoiles, in Connoissance des Temps pour l'Année bissextile 1784, Imprimerie Royale, Paris, p. 227

Nilson P., 1973, Uppsala General Catalogue of Galaxies, Acta Univ. Uppsala, Ser. V, Vol. 1

Nilson P., 1974, Uppsala Astron. Obs. Report 5

Paturel G., 1989, A&AS 80, 299

Paturel G., Fouqué P., Bottinelli L., Gouguenheim L., 1989a, Monographies de la base de données extragalactiques No. 1 (Vols. I, II and III)(ISBN 2.908288.00.1)

Paturel G., Fouqué P., Buta R.J., Garcia A.M., 1991, A&A 243, 319

Paturel G., Petit C., Kogoshvili N., Dubois P., Bottinelli L., Fouqué P., Garnier R., Gouguenheim L., 1991a, A&AS 91, 371 (Paper IV)

Paturel G., Bottinelli L., Gouguenheim L., 1994, A&A 286, 76

Paturel G., Garnier R., Petit C., Marthinet M.C., 1996, A&A 311, 12

Peebles P.J., 1976, ApJ 205, 318

Prugniel P., Simien F., 1995 (private communication)

Rodgers A.W., Peterson B.A., Harding P., 1978, ApJ 225, 768

Rood H.J., Baum W.A., 1967, AJ 72, 398

Rousseau J., Di Nella H., Paturel G., Petit C., 1996, MNRAS 282, 144

Sandage A., Tammann G., 1990, ApJ 365, 1

Saito M., et al., 1990, PASJ 42, 603

Simien F., de Vaucouleurs G., 1986, ApJ 302, 564

Smith M.G., Aguirre C., Zemelman M., 1976, ApJS 32, 217

Takase B., Miyauchi-Isobe N., in Kiso Survey for Ultraviolet-excess Galaxies, 1984, Ann. Tokyo Astron. Obs. 19, 595, 1985, 20, 237, 1985, 20, 335, 1986, 21, 127, 1986, 21, 181, 1987, 21, 251, 1987, 21, 363, 1988, 22, 41, 1989, 1, 11, 1989, 1, 97, 1990, 1, 181, 1991, 2, 7, 1991, 2, 37, 1991, 2, 229, 1992, 2, 399, 1992, 2, 573, 1993, 3, 21, 1993, 3, 169

Tully R.B., Fisher J.R., 1977, A&A 54, 661

Tully R., Fouqué P., 1985, ApJS 58, 67

Valentijn E.A., 1990, Nat 346, 153

Valentijn E.A., 1994, MNRAS 266, 614

Van den Bergh S., 1960, ApJ 131, 215

Vaucouleurs G.de, Vaucouleurs G.de, 1964, Bright Galaxy Catalogue. University of Texas Press, Austin (RC1=BGC)

Vaucouleurs G.de, Vaucouleurs A.de, Corwin H.G., 1976, Second Reference Catalogue of Bright Galaxies. University of Texas Press, Austin (RC2)

Vaucouleurs G.de, 1979, ApJ 227, 380

Vaucouleurs G.de, Vaucouleurs A.de, Corwin H.G., Buta R.J., Paturel G., Fouqué P., 1991, Third Reference Catalogue of Bright Galaxies. Springer-Verlag (RC3)

Vorontsov-Velyaminov B.A., Arkipova V.P., Kranogorskaja A.A., 1963-1974, Morphological Catalogue of Galaxies, Trudy Sternberg Stat. Astr. Inst. 32, Vol. I, 1962, 33, Vol. III, 1963, 34, Vol. II, 1964, 38, Vol. IV, 1968, 46, Vol. V, 1974

Vorontsov-Velyaminov B.A., 1977, (interacting galaxies), A&AS 28, 1

Weinberger R., 1980, A&AS 40, 123

Whitmore B.C., Mc Elroy D.B., Tonry J., 1985, ApJS 59, 1

Yahil A, Tammann G.A., Sandage A., 1977, ApJ 217, 903

Zwicky F., et al., 1961-1968, Catalogue of galaxies and clusters of galaxies, California Institute of Technology, Vol. 1, 1961, Vol. 2, 1963, Vol. 3, 1966, Vol. 4, 1968, Vol. 5, 1965, Vol. 6, 1968

Zwicky F., 1971, Catalogue of Selected Compact Galaxies and of post-eruptive galaxies

Zwicky F., Sargent W.L.W., Kowal C., 1975, AJ 80, 545