now given on four lines, all on the same page, separated by horizontal lines. Vertical lines separating columns have been suppressed. The galaxies are listed in order of right ascension for the year 2000 (first column, line 1), but the still commonly used 1950 coordinates are given on line 4, making it easy to calculate the 100-year precession which is no longer listed separately. Column 2 gives some of the more common names and designations of each object in several catalogues. A more detailed description of the other entries is given in the following section.

Because of the sheer bulk of the literature references, we could not continue the simple scheme used in RC1 and RC2, where detailed references were given explicitly for each galaxy.[12] Instead, we used a two-step scheme, devised by A. de Vaucouleurs, whereby numbered references coded by category (*e.g.*, Dimensions, Description, Photography, Photometry, etc.; see Section 4.1) are listed for each galaxy in the main reference table and a similarly coded "Reference Cross Index" gives the actual literature reference (*i.e.*, journal or publication, volume, page, year). Over 6,500 references for 4,334 galaxies are given for the period 1976 to 1987 inclusive (with a few for 1975 not given in RC2). The literature search was done by A. de Vaucouleurs to the end of 1986, and completed to the end of 1987 by R. Buta who checked all the partial listings for duplication before compiling the final tables. More recent references can be found in the NASA/IPAC Extragalactic Database (Helou *et al.* 1990). References marked with an asterisk in the Cross Index include long tables of data which are not repeated in the primary reference table to individual galaxies. For example, if the radial velocity of M 87 appears among many others in a redshift catalogue, no reference to that catalogue is given in the list of individual references for M 87. These references are simply given as major sources of data in each category. Most of these sources were used in our compilations of diameters, magnitudes, optical and radio redshifts, etc., several of which have been or will be published in the University of Texas *Monographs in Astronomy*, or in the *Monographies de la Base de Données Extragalactiques* (Observatoire de Lyon), and to which the interested reader may refer as needed.

2. The Catalogue

The data for each galaxy are found on four successive lines on a single page. The entries are as follows:

Column 1: Positions

- **Line 1: RA** and **DEC** = right ascension and declination for the equinox 2000.0, precessed from the 1950.0 position in Column 1, Line 4, given to 0.1 second of time and 1 arcsec when available, and to 0.1 minute of time and 1 arcmin otherwise (Section 3.1.a).
- **Line 2: l** and **b** = galactic longitude and latitude in the IAU 1958 system (Blaauw *et al.* 1960), both to $0^\circ.01$.

[12] At the request of some users, we reproduce in this volume the Notes and References of RC1 and RC2 – corrected when necessary – to regroup all references to each galaxy in a single volume.

Line 3: SGL and **SGB** = supergalactic longitude and latitude in the RC2 system (Section 3.1.b), both to 0°01.

Line 4: RA and **DEC** = right ascension and declination for the equinox 1950.0 (Section 3.1.a).

Column 2: Names = commonly used designations for the galaxies (Section 3.2).

Line 1: Names (*e.g.*, LMC, SMC) or NGC and IC designations.

Line 2: UGC (Nilson 1973), ESO (Lauberts 1982), MCG (Vorontsov-Velyaminov *et al.* 1962–1974), UGCA (Nilson 1974), and CGCG (Zwicky *et al.* 1961–1968) designations, given in that order of preference. MCG designations not listed here are given in UGC and ESO.

Line 3: Other common designations (see Table 1 for a complete list).

Line 4: PGC (Paturel *et al.* 1989a,b) designation. For cross identifications of various catalogues with PGC, see Appendix 10.

Column 3: Types and Luminosity Classes

Line 1: Type = mean revised morphological type in the RC2 system, coded as in RC2 (Section 3.3.a).

Line 2: $\mathbf{S_T}$ **and** $\mathbf{n_L}$ = sources of revised type estimates and number of luminosity class estimates.

Line 3: T = mean numerical index of stage along the Hubble sequence in RC2 system, coded as explained in Section 3.3.c, and its mean error.

Line 4: L = mean numerical luminosity class in RC2 system, coded as explained in Section 3.3.d, and its mean error.

Column 4: Optical Diameters and Axis Ratios

Line 1: $\mathbf{\log D_{25}}$ = mean decimal logarithm of the apparent major *isophotal* diameter measured at or reduced to surface brightness level $\mu_B = 25.0$ B-m/ss, and its mean error, as explained in Section 3.4.a. Unit of D is 0.1 arcmin to avoid negative entries.

Line 2: $\mathbf{\log R_{25}}$ = mean decimal logarithm of the ratio of the major isophotal diameter, D_{25}, to the minor isophotal diameter, d_{25}, measured at or reduced to the surface brightness level $\mu_B = 25.0$ B-m/ss, and its mean error, as explained in Section 3.4.b.

Line 3: $\mathbf{\log A_e}$ = decimal logarithm of the apparent diameter (in 0.1 arcmin) of the "effective aperture," the circle centered on the nucleus within which one-half of the total B-band flux is emitted, and its mean error, both derived as explained in Section 3.4.c.

Line 4: $\log D_o$ = decimal logarithm of the isophotal major diameter corrected to "face-on" (i = 0°), and corrected for galactic extinction to $A_g = 0$, but not for redshift, as explained in Section 3.4.d.

Column 5: Major Axis Position Angle, Galactic and Internal Extinctions

Line 1: p. a. = position angle, measured in degrees from north through east (all < 180°), taken when available from UGC, ESO, and ESGC (and in a few cases from H I data) (Section 3.5.a).

Line 2: A_g = Galactic extinction in B-band magnitudes, calculated following Burstein and Heiles (1978a,b, 1982, 1984), as explained in Section 3.5.b.

Line 3: A_i = internal extinction in B-band magnitudes (for correction to face-on), calculated from log R and T, as explained in Section 3.5.c.

Line 4: A_{21} = H I line self-absorption in magnitudes (for correction to face-on), calculated from log R and T $\geq$ 1, as explained in Section 3.5.d.

Column 6: Optical and Infrared Magnitudes

Line 1: B_T = total (asymptotic) magnitude in the B system, and its mean error, derived by extrapolation from photoelectric aperture-magnitude data, B_T^A, and from surface photometry with photoelectric zero point, B_T^S, as explained in Section 3.6.a. The magnitude is followed by an "M" when it is the weighted mean of B_T^A and B_T^S, by a "V" when it is a V-band magnitude rather than a B-band magnitude, and by a "v" when the nucleus of the galaxy is variable. The magnitude is replaced by an asterisk (*) when deriving B_T^A would have required an extrapolation in excess of 0.75 mag.

Line 2: m_B = photographic magnitude and its mean error from Ames (1930), Shapley and Ames (1932), CGCG, Buta and Corwin (1986), and/or Lauberts and Valentijn (1989) reduced to the B_T system, as explained in Section 3.6.b.

Line 3: m_{FIR} = far-infrared magnitude calculated from $m_{FIR} = -20.0 - 2.5 \log \mathrm{FIR}$, where FIR is the far infrared continuum flux measured at 60 and 100 microns as listed in the *IRAS Point Source Catalog* (1987). For galaxies larger than 8′ in RC2 and for the Virgo cluster area, resolved by the IRAS beam, integrated fluxes are taken from Rice *et al.* (1988) or Helou *et al.* (1988). See Section 3.6.c for details.

Line 4: B_T^o = total "face-on" magnitude corrected for Galactic and internal extinction, and for redshift, as explained in Section 3.6.d.

Column 7: Total Color Indices

Line 1: $(B-V)_T$ = total (asymptotic) color index in the Johnson B−V system, and its mean error, derived by extrapolation from photoelectric color-aperture data, and/or from surface photometry with photoelectric zero point, as explained in Section 3.7.a.

Line 2: $\mathbf{(U-B)_T}$ = total (asymptotic) color index in the Johnson U−B system, and its mean error, derived by extrapolation from photoelectric color-aperture data, and/or from surface photometry with photoelectric zero point, as explained in Section 3.7.a.

Line 3: $\mathbf{(B-V)_T^o}$ = total B−V color index corrected for Galactic and internal extinction, and for redshift, as explained in Section 3.7.b.

Line 4: $\mathbf{(U-B)_T^o}$ = total U−B color index corrected for Galactic and internal extinction, and for redshift, as explained in Section 3.7.b.

Column 8: Effective Color Indices and B-band Surface Brightness

Line 1: $\mathbf{(B-V)_e}$ = mean B−V color index, and its mean error, within the effective aperture A_e, derived by interpolation from photoelectric color-aperture data, as explained in Section 3.7.a.

Line 2: $\mathbf{(U-B)_e}$ = mean U−B color index, and its mean error, within the effective aperture A_e, derived by interpolation from photoelectric color-aperture data, as explained in Section 3.7.a.

Line 3: $\mathbf{m'_e}$ = mean B-band surface brightness in magnitudes per square arcmin (B-m/sm) within the effective aperture A_e, and its mean error, calculated by the relation $m'_e = B_T + 0.75 + 5 \log A_e - 5.26$. This m'_e is statistically related to the effective mean surface brightness, μ'_e (RC2, p. 31; Olson and de Vaucouleurs 1981), with which it coincides when $\log R = 0$ ($i = 0°$) (Section 3.8.a).

Line 4: $\mathbf{m'_{25}}$ = the mean surface brightness in magnitudes per square arcmin (B-m/sm) within the $\mu_B = 25.0$ B-m/ss elliptical isophote of major axis $\log D_{25}$ and axis ratio $\log R_{25}$, defined as in RC2 (Equation 21) by:

$$m'_{25} = B_T + \Delta m_{25} + 5 \log D_{25} - 2.5 \log R_{25} - 5.26,$$

where $\Delta m_{25} = 2.5 \log L_T/L_{25} = B_{25} - B_T$ is the magnitude increment contributed by the outer regions of a galaxy fainter than $\mu_B = 25.0$ B-m/ss. For details, see Section 3.8.b.

Column 9: 21-cm Magnitude and Linewidths, Hydrogen Index

Line 1: $\mathbf{m_{21}}$ = 21-cm emission line magnitude, and its mean error, defined by $m_{21} = 21.6 - 2.5 \log S_H$, where S_H is the measured neutral hydrogen flux density in units of $10^{-24}\,\mathrm{W\,m^{-2}}$. For details, see Section 3.9.a.

Line 2: $\mathbf{W_{20}}$ = neutral hydrogen line full width (in $\mathrm{km\,s^{-1}}$) measured at the 20% level (I_{20}/I_{max}), and its mean error, as explained in Section 3.9.b.

Line 3: $\mathbf{W_{50}}$ = neutral hydrogen line full width (in $\mathrm{km\,s^{-1}}$) measured at the 50% level (I_{50}/I_{max}), and its mean error, as explained in Section 3.9.b.

Line 4: *HI* = corrected neutral hydrogen index, which is the difference $m^{\circ}_{21} - B^{\circ}_{T}$ between the corrected (face-on) 21-cm emission line magnitude and the similarly corrected magnitude in the B_T system. Details are given in Section 3.9.c.[13]

Column 10: Radial Velocities

Line 1: $V_{21} = cz$ is the mean heliocentric radial velocity, and its mean error, in km s^{-1} derived from neutral hydrogen observations, as explained in Section 3.10.a.

Line 2: $V_{opt} = cz$ is the mean heliocentric radial velocity, and its mean error, in km s^{-1} derived from optical observations, as explained in Section 3.10.b.

Line 3: V_{GSR} = the weighted mean of the neutral hydrogen and optical velocities, corrected to the "Galactic standard of rest," as explained in Section 3.10.c.

Line 4: V_{3K} = the weighted mean velocity corrected to the reference frame defined by the 3°K microwave background radiation, as explained in Section 3.10.d.

3. Explanation of sources and reduction of data to standard systems

This section gives detailed information on the catalogue entries that are not self-explanatory.

3.1. Positions

a. Equatorial coordinates (Column 1, Lines 1 and 4)

Equatorial coordinates for the equinoxes of 1950.0 and 2000.0 are given to $0^{s}.1$ and $1''$ when precise positions are available.[14] These coordinates typically have mean errors of $\pm 5''$–$10''$, although some (*e.g.*, for the nuclei of M 31 and M 33 from de Vaucouleurs and Leach 1981) are much more precise. Most of the measurements of these precise coordinates were referred to SAO stars, so that the coordinates are nominally on the FK4 system. However, 6,043 galaxies listed here do not yet have precise coordinates. For these, the equatorial coordinates are given to $0^{m}.1$ and $1'$ and are taken from (in order of preference) CGCG, UGC, MCG, or the publication from which additional data for the galaxy were taken. All known corrections to published positions were taken into account. The catalogue is ordered by the equinox 2000.0 positions which were precessed from the 1950.0 positions using the 1976 IAU constants (see, *e.g.*, the *Supplement* to *The Astronomical Almanac* for 1984).

b. Galactic coordinates (Column 1, Line 2)

Galactic coordinates, l and b, given to $0^{\circ}.01$, are calculated following the IAU 1958 prescription (Blaauw *et al.* 1960) with the North Galactic Pole at $\alpha = 12^{h}49^{m}$, $\delta = +27^{\circ}24'$ (1950), and the origin at $\alpha = 17^{h}\,42^{m}.4$, $\delta = -28^{\circ}55'$ (1950).

[13]Since m_{21} and B_T are listed separately in columns 6 and 9, line 1, there is no need to print the uncorrected index.

[14]Paturel *et al.* (1989a,b) give a complete list of references for the precise equatorial coordinates used here.

The corrections for inclination effects are entirely different from those adopted in RC2 after H^2V (1971), where galaxies of all types were treated as optically thin oblate spheroids that become brighter and apparently larger when the inclination increases from the face-on view (i = 0°) to edge-on (i = 90°). After considerable statistical study, we have adopted the view that at least spirals ($0 < T < 10$) are substantially optically thick at the 25.0 B-m/ss isophote level, and behave essentially as opaque disks. That is, they have apparent isophotal diameters independent of inclination. The evidence will be reported elsewhere (see also Valentijn 1990). Hence, no inclination-dependent correction needs to be applied to log D_{25} for spirals ($T > 0$). For $T < 0$, which are certainly optically thin at the 25.0 B-m/ss level, the situation is complicated because of the probable prolateness or triaxiality of at least some of the elliptical galaxies and related types (some I0 types), while lenticulars are generally disk systems, but are not dust-free. We have, therefore, adopted the following values of the coefficient of log R_{25} in the equation,

$$\log D(0)_{25} = \log D_{25} - C \log R_{25}, \tag{19}$$

with $C = 0.3$ for the E class ($-6 \leq T \leq -4$), 0.15 for the L class ($-3 \leq T \leq -1$), 0.05 for $T = 0$, and $C = 0.0$ for all $T > 0$, although there is some evidence that $C > 0$ for $T = 10$.

3.5. Position angle, Galactic and internal extinction

a. Position angle p.a. (Column 5, Line 1)

The position angle, p.a. < 180°, of the major axis measured in degrees from North eastward for the 1950.0 equinox is taken from UGC, ESO-B, and ESGC, in that order of preference. The mean error is unknown, but increases when log R decreases. Generally, no value is given when log $R_{25} \lesssim 0.10$. Altogether, position angles are listed for 15,293 objects or 66.4% of the catalogue.

b. Galactic extinction A_g (Column 5, Line 2)

The Galactic extinction in the B-band, A_g(B), expressed in magnitudes, is calculated from the value of E(B−V) predicted by the method of Burstein and Heiles (BH; 1978a,b, 1982, 1984). The values adopted here were calculated by D. Burstein as described in the last reference. This model predicts reddening for Galactic latitudes $|b| > 10°$ using a combination of local (Galactic) H I column density and faint galaxy counts north of $\delta = -23°$, the southern limit of the Lick counts (Shane and Wirtanen 1967), and H I column density only south of −23°. There is some evidence (Burstein *et al.* 1987) that the BH H I-based extinction prediction is a factor of 2 overestimate in the region $230° < l < 310°$, $-20° < b < +20°$.

The B-band extinction was calculated as $A_g(B) = 4.3\,E(B-V)$, where the coefficient is appropriate for the mean color index of galaxies. For those galaxies that have directly measured colors, a more accurate value of the coefficient would be $\mathbf{R} + 1 = 4.25 + 0.25\,(B-V)_o + 0.05\,E(B-V)$ (Olson 1975). Except for a few heavily obscured galaxies, the difference would be less than the uncertainty in the BH values, estimated at 0.06 mag for $A_g \leq 0.6$ mag, and 0.10 A_g for $A_g > 0.6$ mag. It was assumed that $A_g = 0$, where $E(B-V) \leq 0.00$.

Many galaxies do not have reddenings listed in the BH tables, either because they lie below $|b| = 10°$, or they are in regions where there are no H I data (*e.g.*, within a few degrees of the South Galactic Pole). For 622 of these galaxies, Dr. Burstein kindly estimated reddenings for us by extrapolating or interpolating values from nearby regions with H I data. For the remaining galaxies – all within 9°4 of the galactic plane, or at $b \leq -63.°8$ – we used a mean relation to convert RC2 absorption estimates[27] into the BH system:

$$\log A_g(\mathrm{BH})/A_g(\mathrm{RC2}) = -0.0146(|b| - 11), \qquad \sigma = 0.10. \tag{20}$$

The mean precision of the BH absorptions predicted by this formula is about 20%. We searched for, but did not find, any significant differences between the northern and southern Galactic hemispheres in this conversion formula.

Values of A_g are listed for 23,015 galaxies or 99.96% of the catalogue, but values for 757 objects in excess of 1 mag should be regarded as tentative only, except for a few heavily obscured galaxies for which direct estimates of A_g were used instead of the BH values as follows: Circinus: 2.3 (Freeman *et al.* 1977, RC2), Maffei I: 6.6 (Buta and McCall 1983), Maffei II: 8.1 (Spinrad *et al.* 1973, Buta and McCall 1983), IC 10: 3.5 (de Vaucouleurs and Ables 1965), and IC 342: 3.5 (McCall 1989). For M 31, the value for M 32 was adopted, following Burstein and Heiles (1984).

c. Internal extinction A_i (Column 5, Line 3)

The dimming of the B-band apparent luminosity by internal dust in a disk galaxy, A_i, expressed in magnitudes, is a function of inclination, which can be conveniently expressed as a linear function of log R_{25} (see H²V 1971, p. 101 and RC2, Equation 24, p. 33)

$$A_i = \alpha(\mathrm{T}) \log \mathrm{R}_{25}. \tag{21}$$

The extinction coefficient $\alpha(\mathrm{T})$ depends on type, but its exact value is uncertain because of biases in the galaxies selected for photometry. After extensive statistical analyses (to be reported elsewhere), the following interpolation formula was adopted:

$$\begin{aligned} \alpha(\mathrm{T}) &= 1.5 - 0.03(\mathrm{T}-5)^2 && \text{for } \mathrm{T} \geq 0, \\ \alpha(\mathrm{T}) &= 0 && \text{for } \mathrm{T} < 0. \end{aligned} \tag{22}$$

This correction is about double that used in RC2 and larger than that advocated by Haynes and Giovanelli (1984). When $\log \mathrm{R}_{25} > 1$, it was assumed to be $= 1.0$ to avoid excessively large corrections. Note that in the absence of scattering by dust, and if the surface brightness of galaxies were exactly constant and independent of inclination, the coefficient should be 2.5. However, forward scattering by dust will cause this coefficient to decrease, with current estimates predicting it to be ≈ 1.8 (Bruzual *et al.* 1988). Values of A_i (range 0.0 to 1.5) are listed for 21,116 galaxies with an average of 0.33 mag and estimated mean errors of 10% or up to 0.15 mag, except for T = 0 and 10, where it could reach 30% or up to 0.3 mag.

[27] The formulae printed in RC2 have incorrect coefficients for the longitude dependent terms. However, the correct formulae, given by de Vaucouleurs and Buta (1983, Appendix C), were used to calculate the A_{B} values printed in the main catalogue.

d. H I line self-absorption A_{21} (Column 5, Line 4)

Fits vs. log R_{25} of the residuals of the correlation of $y = m_{21}$ and $x = 5 \log D_{25}$, calculated from the impartial regression line $<y(x)>$, that is, $y(x) - <y(x)> = a + b \log R_{25}$, in the range $11 < m_{21} < 17$, give consistently positive values, which, within errors, are independent of type. In the mean, for all $T \geq 1$, $b = 0.50 \pm 0.08$ (n = 3631 residuals). If log D_{25} is independent of inclination for these types, this result indicates substantial internal self-absorption in the 21-cm line, up to 0.5 mag in edge-on galaxies ($\log R = 1$), far in excess of our expectation (see H^2V, p. 96 and RC2, p. 41), but in agreement with Haynes and Giovanelli (1984). The 21-cm line self-absorption, computed as $A_{21} = 0.5 \log R_{25}$, is listed for 15,691 galaxies of types $T \geq 1$, or 99.5% of all galaxies of these types in the catalogue. To avoid excessive corrections, values of log $R_{25} \geq 1$ were treated as = 1. Thus, the maximum correction is 0.5 mag and the average 0.15 mag. No correction was applied to galaxies of types $T < 1$, because in early-type galaxies, the H I emission is not so closely confined to an equatorial plane and is usually very weak, suggesting that self-absorption may be negligible.

3.6. Optical and infrared magnitudes

a. Photoelectric total magnitude B_T (Column 6, Line 1)

The total (or asymptotic) B-band magnitudes can be derived by two methods:

1. Extrapolation of photoelectric aperture photometry by means of standard curves (B_T^A)
2. Extrapolation of photoelectrically calibrated surface photometry (pg or CCD) (B_T^S).

1. Total magnitudes from aperture photometry Values of B_T^A were derived by R. Buta for 3,489 galaxies from 22,475 B-band observations contained in the Revised UBV Catalogue (RUBV).[28] The RUBV, prepared by R. Buta, includes all the photometry in the compilation of Longo and A. de Vaucouleurs (1983), and its supplement (1985), plus all post-supplement sources to the end of 1986 (collected by A. de Vaucouleurs) to which were added about 2,000 measurements by Burstein *et al.* (1987) and 1,500 unpublished measurements made at the McDonald Observatory by R. Buta, H. Corwin, M. Frueh, J. Higdon, S. Mitra, and S. Odewahn. The full RUBV includes 5,051 galaxies and contains 25,747 B, 25,962 V, 24,862 B−V, and 16,781 U−B measurements. For 1,562 galaxies, the available photoelectric data were inadequate to determine B_T^A. However, if a B_T^S is available for any of these objects, it is given instead.

The mean B-band standard curves, compiled in Table 11 and shown in Figure 2, are post-RC2 revisions (de Vaucouleurs and Corwin 1977, unpublished). The main change from the RC2 curves (RC2, Figure 5, p. 24) is that the large gap between the standard curves for elliptical and lenticular galaxies has been greatly reduced, in agreement with most recent studies indicating more continuity between these two classes. In addition, standard curves

[28] The photographic observations of Holmberg (1958), previously reduced to the B system (de Vaucouleurs *et al.* 1977a), were used also at the nominal aperture $A = \sqrt{ab}$, where a, b are the major and minor diameters measured by Holmberg.

is dominated by thermal emission – normally peaks between 50 and 100 μm (see Helou *et al.* 1988 for further discussion). Note that many galaxies well-detected in the IRAS 60 and 100 μm bands are not detected, or have only upper limit "detections," in the 12 and 25 μm bands. Thus, other formulations of $m_{\rm FIR}$ (*e.g.*, that of Martin *et al.* 1989) may overestimate the far-infrared flux compared with the values listed in the IRAS catalogue, which were adopted here.

Galaxies larger than 8 arcmin are well-resolved by the IRAS "beams" (FWHM $\sim 2'$ for the *Point Source Catalog*, and $\sim 8'$ for the *Small Scale Structure Catalog*), so FIR for 76 optically large objects (selected from RC2) is taken from Rice *et al.* (1988; called "$F_{\rm IR}$" by them and listed in their Table 4, Column 5). Helou *et al.* (1988) have also listed FIR for 133 galaxies in the area of the Virgo Cluster. Both Rice *et al.* and Helou *et al.* have used *all* available IRAS data for these galaxies, not just the all-sky scans reduced for the *Point Source* and *Small Scale Structure Catalogs*. This has at least doubled the IRAS sensitivity for these 205 objects,[35] so that $m_{\rm FIR}$ for them will have smaller errors (up to about 10% $\simeq$ 0.1 mag) than $m_{\rm FIR}$ taken from the *Point Source Catalog* (errors can be up to 50% $\simeq$ 0.75 mag).

Altogether, $m_{\rm FIR}$ is listed for 5,321 galaxies, or 23.1% of the catalogue.

d. Corrected total magnitude B_T^o (Column 6, Line 4)

The total "face-on" magnitude B_T^o corrected for galactic and internal absorption, and for redshift, is given, as in RC2, by:

$$B_T^o = B_T(A_g = 0, A_i = 0, z = 0) = B_T - A_g - A_i - K_{\rm B}\, z, \tag{51}$$

but with different extinction corrections. The galactic extinction is from Column 5, line 2, and the internal differential extinction from Column 5, line 3 (Section 3.5.c).

As in RC2, the K correction for redshift ($z < 0.05$) is given by

$$K_{\rm B}(z, {\rm T}) = K_{\rm B}({\rm T}) \cdot z = K'_{\rm B}({\rm T}) \cdot cz, \tag{52}$$

where cz is the observed heliocentric velocity (Column 10, Line 1 or 2) in km s^{-1} and

$$\begin{aligned} 10^4 \cdot K'_{\rm B}({\rm T}) &= 0.15 && \text{for T} \leq 0, \\ &= 0.15 - 0.025{\rm T} && \text{for } 0 \leq \text{T} \leq 3, \\ &= 0.075 - 0.010({\rm T} - 3) && \text{for T} \geq 3, \end{aligned} \tag{53}$$

after Pence (1976). The maximum correction for $cz = 1.5 \cdot 10^4$ km s^{-1} is 0.2 mag for T ≤ 0 and 0.1 mag for T > 3. Corrected total magnitudes are listed for 12,487 galaxies or 54.2% of the catalogue. No mean errors are given, but could be readily calculated from the listed mean errors in B_T or $m_{\rm B}$, T, log R_{25}, and the estimated errors in A_g and A_i. The errors in cz and in the K corrections are comparatively negligible.

[35] Four objects – NGC 4192, NGC 4216, NGC 4438, and NGC 4569 – are in both lists. The mean difference, $\Delta m_{\rm FIR} = m_{\rm FIR}(H) - m_{\rm FIR}(R) = -0.08 \pm 0.08$ ($m.e.$; $\sigma = 0.15$) is not significant.

where m'_e is expressed in magnitude per square arcminute (m/sm) when A_e is in *tenths* of arcminutes and $m_T = B_T$ (Column 6, Line 1). The theoretical relation between m'_e and μ'_e is, to first order,

$$\mu'_e = m'_e - 1.3(\log R_{25})^2, \tag{71}$$

where the coefficient is a close enough average of the exact values (1.35 and 1.26) for the $r^{1/4}$ and exponential laws of luminosity distribution (Olson and de Vaucouleurs 1981).

Values of m'_e were computed for 2,595 galaxies having B_T and A_e values, or 11.3% of the catalogue. The mean error was not calculated by propagating the errors in B_T and $\log A_e$, because these quantities are correlated. The catalogue gives an error (average 0.11 B-m/ss) based on the range of m'_e implied by the internal errors in B_T^A and $\log A_e$.

b. Mean surface brightness within the 25th B-m/ss isophote m'_{25} (Column 8, Line 4)

The mean surface brightness in magnitudes per square arcminute (B-m/sm), within the μ_B = 25.0 B-m/ss elliptical isophote of major axis D_{25} and axis ratio R_{25}, is defined as in RC2 (Equation 21) by

$$m'_{25} = B_T + \Delta m_{25} + 5\log D_{25} - 2.5\log R_{25} - 5.26, \tag{72}$$

where

$$\Delta m_{25} = 2.5\log L_T/L_{25} = B_{25} - B_T \tag{73}$$

is the magnitude increment contributed by the outer regions of a galaxy fainter than μ_B = 25.0 B-m/ss. The average values derived in RC2 from the standard curves and mean $\log \rho(0)$ for each class, ΔB_{25} = 0.25 (E), 0.13 (L) and 0.11 ($T \geq 0$), were adopted for consistency. It is clear that there is no constant relation between m'_{25} and m'_e or μ'_e, since the ratio between an isophotal diameter, such as D_{25}, and metric diameters, such as D^*_e or A_e, will vary not only with type, but also with the surface brightness itself. However, m'_{25} is a useful index of surface brightness that can be calculated for a larger fraction of the catalogued objects than either m'_e or μ'_e. Values of m'_{25} are given with an average mean error of 0.33 magnitude (range 0.067 to 1.73) for 3,638 galaxies, or 15.8% of the catalogued objects. For galaxies having both m'_{25} and m'_e, there is a loose correlation between the two surface brightness parameters with a dispersion of about 0.5 magnitude in m'_e at a given m'_{25}. A detailed discussion will be presented elsewhere.

3.9. Neutral hydrogen magnitude, linewidths and *HI* index

The 21-cm line fluxes S_H and widths at the 20% and 50% levels, W_{20} and W_{50}, are extracted from the recent catalogue of weighted mean H I data by Bottinelli *et al.* (1990, BGFP) incorporated in the extragalactic data base maintained at Lyons by G. Paturel. The reader is referred to this publication for details of procedures, corrections, and error estimates.

a. H I line magnitude m_{21} (Column 9, Line 1)

The H I line magnitude m_{21} is defined as

$$m_{21} = 16.6 - 2.5 \log S_H \tag{74}$$

where S_H is in units of $10^{-22}\,W\,m^{-2}$, as in RC2.[40] The relation between S_H in units of $10^{-22}\,W\,m^{-2}$ and the line integral $\int S\,dV$ in $Jy\,km\,s^{-1}$ is

$$\log \int S\,dV = \log S_H + 0.3244 + \log(1+z), \tag{75}$$

where the last term is the redshift correction (≤ 0.021 for $cz \leq 15{,}000\ km\,s^{-1}$). The corresponding hydrogen mass factor F_H in units of $10^6 \mathcal{M}_\odot\,Mpc^{-2}$ is

$$F_H = 0.497(1+z)S_H, \tag{76}$$

and the apparent H I mass of a galaxy is given in solar mass units by

$$\log(\mathcal{M}_H/\mathcal{M}_\odot) = \log F_H + 2\log\Delta + 6 = \log S_H + \log(1+z) + 2\log\Delta + 5.696, \tag{77}$$

if the distance Δ is in Megaparsecs. The true H I mass, corrected for self-absorption A_{21}, is derived as explained in Section 3.9.c.

Then, the logarithm of the ratio of neutral hydrogen mass to B-band luminosity, both in solar units, is given by

$- 0.4\,H.I. - 0.4(M_{B\odot} - 5.84) + \log(1+z)$

$$\log(\mathcal{M}_H/L^\circ_B)_\odot = 0.4\,HI + 0.4\,[M_B(\odot) - 5.46], \tag{78}$$ ← wrong.

where HI is the hydrogen index (Section 3.9.c), and $M_B(\odot)$ is the B-band absolute magnitude of the Sun.[41]

Weighted mean H I line magnitudes corrected for beam-filling and reduced to a homogeneous system (see BGFP for details) are listed here for 6,094 galaxies or 26.5% of the catalogue with an average mean error of 0.21 magnitude (range 0.035 – 0.70).

b. H I linewidths W_{20}, W_{50} (Column 9, Lines 2, 3)

The weighted mean H I linewidths at (or reduced to) the 20% and 50% levels, W_{20} and W_{50}, in $km\,s^{-1}$, corrected for bandwidth, but not for redshift; and their mean errors are taken from the BGFP catalogue, where details of the elaborate reduction procedure are given. The average mean errors are 10.4 and 8.3 $km\,s^{-1}$(ranges 2 to 49 and 2 to 37) for 4,204 and 5,233 galaxies (18.3% and 22.7% of the catalogue) generally having redshifts $< 15{,}000\,km\,s^{-1}$.

[40] The exponent −28 on p. 41 of RC2 was an error traceable to omission of a factor 10^6 in H^2V (1971, p. 97). Note that in BGFP, the flux S is in units of $10^{-24}\,W\,m^{-2}$, but the constant in the defining equation is 21.6, resulting in the same magnitude as in RC2 and RC3.

[41] The second term of Equation 78 was −0.02 (de Vaucouleurs 1977a, p.68) when the adopted absolute magnitude of the Sun was +5.41. It is +0.03 for the more recent "best value" of +5.52, corresponding to an apparent magnitude $V_\odot = -26.74$, and color $(B-V)_\odot = +0.69$ (Tüg and Schmidt-Kaler 1982).

c. Corrected H I index *HI* (Column 9, Line 4)

The hydrogen index, *HI*, is defined, as in RC2 (Equation 47, p. 42), by analogy with a color index, as the difference

$$HI = m^{\circ}_{21} - B^{\circ}_{T}, \tag{79}$$

between the H I line and B-band magnitudes, both corrected for redshift and internal extinction (and galactic extinction for B_T). The correction of the H I line flux for self-absorption is uncertain and controversial: a small, semitheoretical correction was applied in RC2 (Equation 45); no correction is favored by many, perhaps most radio astronomers, while others find evidence for a substantial dependence of H I flux on inclination (*i.e.*, axis ratio). Selection and regression effects, Malmquist bias, and other ill-defined biases in the H I line database prevent a definitive solution at the present time. From studies of the dependence on log R of the H I mass (or absolute magnitude M_{21}) in flux-limited samples, preliminary statistics of the RC3 data suggest that significant self-absorption is present at all S stages ($T > 0$), amounting to ≈ 0.5 mag in edge-on objects (Section 3.5.d). The m°_{21} magnitude, corrected for self-absorption, is, therefore, defined as

$$m^{\circ}_{21} = m_{21} - A_{21} = m_{21} - 0.5 \log R_{25}, \tag{80}$$

for all $T \geq 1$, with $\log R_{25}$ set to 1.00 for all $\log R_{25} \geq 1.00$. The correction A_{21}, expressed in magnitudes, is given in Column 5, Line 4.[42] No correction was applied to types $T \leq 0$, which are hydrogen-poor.

Values of *HI* are listed for 4,357 galaxies or 18.9% of the catalogue. The mean errors are not given because of the uncertain extinction corrections, both radio and optical, but may be on the order of 0.3 or 0.4 mag depending on the errors of the input magnitudes and extinction corrections.[43] The mean and median values of *HI* show a smooth trend with morphological type from $\approx$ 2 at $T = 1$ to $\approx$ 0 at $T = 10$.

3.10. Radial velocities (Column 10, Lines 1 to 4)

a. H I line radial velocity V_{21} (Column 10, Line 1)

The heliocentric radial velocity cz in km s^{-1}, calculated with the optical convention, $z = (\lambda - \lambda_\circ)/\lambda_\circ$, derived from the 21-cm line profile, was also taken from BGFP. It is a weighted mean of all nonrejected determinations with its external mean error, calculated as explained in BGFP. Where two or more determinations exist, and one is wildly discrepant, the faulty value was identified, as far as possible, by reference to the optical velocity (Line 2) and rejected.

H I line radial velocities, usually not in excess of 15,000 km s^{-1}, are listed for 6,428 galaxies, or 27.9% of the catalogue. The average mean error is 8.5 (range 2 – 22) km s^{-1}.

[42] Note that in RC2, A_{21} was the correction to $\log S_H$, not to m_{21}.

[43] Users who believe that 21-cm self-absorption is negligible need only to add back the quantity A_{21} to the corrected *HI* index.

Table 14. Zero-point corrections and mean errors of radial velocities.

Source	ZPC	n	σ	Source	ZPC	n	σ
RC1, Source A	22	32	49	Feldman *et al.* 1982	-54	86	72
RC1, Source B	0	422	56	Tifft 1982	0	401	80
RC1, Source C	-33	208	58	Denisyuk and Lipovetski 1983	33	40	61
RC2, Source K3	12	177	72	Huchra *et al.* 1983	0	472	50
RC2, Source S5	22	39	66	Schechter 1983	-14	29	14
RC2, Source Z1	0	171	110	Shectman *et al.* 1983 (Las Campanas)	7	98	25
RC2, Source Z2	-15	115	46	Shectman *et al.* 1983 (Mt. Hopkins)	-14	25	19
Shobbrook 1966	35	14	66	White *et al.* 1983	0	216	56
Doroshenko and Terebizh 1975	59	17	63	Beers *et al.* 1984	-40	28	58
Karachentsev *et al.* 1975, 1976	-25	59	82	Chincarini *et al.* 1984	-33	32	88
de Vaucouleurs, G. & A. 1976	47	37	73	da Costa *et al.* 1984	0	130	34
Turner 1976	24	82	98	Dennefeld and Sèvre 1984	-26	37	76
Kirshner 1977	26	28	48	Markarian *et al.* 1984	21	28	52
Penston *et al.* 1977	-46	12	53	Richter 1984	46	10	61
Bergvall *et al.* 1978	-35	21	63	Dahari 1985	17	68	65
Eastmond and Abell 1978	18	101	96	Elston *et al.* 1985	46	12	46
Sandage 1978	0	419	66	Keel *et al.* 1985	0	117	60
Stoke *et al.* 1978	-24	63	68	Osterbrock and De Robertis 1985	35	20	49
de Vaucouleurs *et al.* 1979	0	123	63	Bushouse 1986	34	30	97
Kunth and Sargent 1979	54	16	82	Dickens *et al.* 1986	45	76	59
Schild and Davis 1979	68	10	55	Davies *et al.* 1987	8	168	37
Karachentsev 1980	0	344	57	Maehara *et al.* 1987	46	33	33
Markarian *et al.* 1980a, b	98	40	97	Maia *et al.* 1987	-17	32	24
Schechter 1980	-14	31	18	Osterbrock and Pogge 1987	-116	23	61
Arp 1981	26	38	69	Smith *et al.* 1987	-14	55	37
Gregory *et al.* 1981	-16	70	52	Hill *et al.* 1988	-61	22	114
Tonry and Davis 1981	0	243	31	Moorwood and Oliva 1988	46	25	96
Tonry 1981	-27	12	20	Menzies *et al.* 1989	0	135	52
West *et al.* 1981	-30	37	86				

that the accuracy of optical spectrographic redshifts has not improved very much over the years, except for special high-dispersion (or interferometric) studies of a few objects. The progress in recent years has been more in the direction of mass production of redshifts than of improving their precision.

Optical redshifts of 9,457 galaxies (or 41.1% of the catalogue) are listed with an average mean error of 55.2 (range 7 – 190) km s^{-1}.

c. Radial velocity corrected to the Galactic Center V_{GSR} (Column 10, Line 3)

The weighted mean radial velocity of the radio and optical redshifts was corrected to the Galactic Standard of Rest, that is, the Galactic Center, by application of corrections for the motions of the Sun relative to the Local Standard of Rest (LSR), and of the latter, relative to the Galactic Center. The sum of these two corrections define the Galactic Standard of Rest (GSR).

The adopted galactocentric velocity components of the V(LSR) of the Sun are X = 9, Y = 12, Z = 7 km s^{-1} (Delhaye 1965), corresponding to a solar velocity of 16.5 km s^{-1} toward an apex at $l = 53°$, $b = +25°$.

The adopted galactic rotation of the LSR, as recommended by the IAU in 1985 (see also de Vaucouleurs 1983), is Y = 220 km s^{-1} (X = 0, Z = 0) toward $l = 90°$, $b = 0°$. The total solar velocity vector is thus X = 9, Y = 232, Z = 7 $km\,s^{-1}$ or 232.3 $km\,s^{-1}$ toward $l = 87^\circ\!.8$, $b = +1^\circ\!.7$, and the corrected radial velocity of a galaxy is

$$V_{GSR} = <V> + 9 \cos l \cos b + 232 \sin l \cos b + 7 \sin b, \quad (81)$$

where $<V>$ is the weighted mean of V_{21} and V_{opt}. If the radio and optical velocities differ by more than 1,000 $km\,s^{-1}$, and there is no way of resolving the disagreement, V_{GSR} is not calculated. Its absence indicates that new observations are needed.

Velocities reduced to the Galactic Standard of Rest are listed for 16,659 galaxies or 72.4% of the catalogue. No mean error is attached, but it could be readily calculated from the sum of the weights of V_{21} and V_{opt}.[45]

d. Radial velocities corrected to the reference frame of the background radiation V_{3K} (Column 10, Line 4)

The mean velocity $<V>$ is reduced to the reference frame defined by the background radiation, assuming a total solar motion of 360 ± 25 $km\,s^{-1}$ toward $\alpha = 11^h15^m \pm 9^m, \delta = -5^\circ\!.6 \pm 2^\circ\!.0$ (1950), after Lubin and Villela (1986).[46] Thus,

$$V_{3K} = <V> - 351 \cos\alpha \cos\delta + 70 \sin\alpha \cos\delta - 35 \sin\delta. \quad (82)$$

4. Explanation of References, Notes, and Appendices

4.1. References

As explained in the Introduction, the vastly larger number of extragalactic literature references demanded a new scheme for their presentation. Unlike RC1 and RC2, the Notes and References have been separated (the Notes are described in the next section).

Locating a particular reference for a particular galaxy is now a two-step procedure: (1) Find the desired galaxy in the NGC, IC, or A tables, which list reference numbers within a particular category (*e.g.*, "Redshifts, optical," "Interstellar Medium," etc.), then (2) locate the reference(s) by category and number in the Reference Cross Index. The categories are listed in Table 15 and, for convenience, at the beginning of the Reference section.

We also give, before the A table, a list of cross identifications of new A ("anonymous") designations and the corresponding PGC numbers (the RC2 A galaxies are identified by PGC number in Appendix 10). In many cases, especially those where radio and x-ray sources are identified with faint galaxies, the object is clearly not in PGC, and, therefore, is not in the main RC3 table. We have, nevertheless, retained the reference to the object for the sake of completeness. In many other cases, we could not determine the PGC number for a galaxy

[45] We do not list the velocity V_o reduced to the ill-defined frame of the Local Group (see RC2, p. 49).

[46] Note that the amplitude of the velocity vector depends not only on the measured amplitude of the dipole term $\Delta T/T = (1.207 \pm 0.085) \cdot 10^{-3}$, but also on the assumed value for the best-fitting blackbody temperature, T = 2.7°K.