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The Peculiar Motions of Early-Type Galaxies in Two Distant Regions III: The Photometric Data

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ABSTRACT

We present R-band CCD photometry for 776 galaxies observed in the EFAR project. The photometry is compared with photoelectric data, showing that a common zero-point good to better than 1 percent and a precision of 0.03 mag per zero-point have been achieved. We give the circularly averaged surface brightness profiles and the photometric parameters of the 762 program galaxies, D_n diameters (at 20.5 mag arcsec^{-2}), half-luminosity radii R_e, total magnitudes m_T and average effective surface brightnesses $\langle SB_e \rangle$. The photometric parameters are derived using the seeing-convolved, $R^{1/4}$ plus exponential fitting algorithm described in Paper IV which optimally combines multiple profiles and corrects for sky subtraction errors. The parameters of the two-component fits are also given.

We find that the diameters D_n span the range 4.8-90 arcsec, with $\langle \log D_n \rangle = 1.30$ or 20 arcsec. The run of the effective radii R_e is 1.6-71.2 arcsec, with $\langle \log R_e \rangle = 0.84$ or 6.9 arcsec. The total magnitudes m_T extend from 10.57 to 15.97 mag, with a mean of 13.85 mag. The effective surface brightnesses $\langle SB_e \rangle$ span the range 17.78-22.35 mag arcsec^{-2} with a mean of 19.89 mag arcsec^{-2}. The mean *photometric* precision of D_n diameters, magnitudes and surface brightnesses is 0.9%, 0.017 mag and 0.017 mag arcsec^{-2} respectively. In addition, the fitting scheme quantifies and minimises the many *systematic* biases affecting the determination of galaxy photometric parameters. We find simple $R^{1/4}$ fits for only 14% of the total, and simple exponential fits for ≈ 1% of the total. The spread in sky values measured from the different profiles of the same object is less than 1% in 85% of the cases. In 80% of the fits a reduced χ^2 less than 12 is obtained. More than 90% of the galaxies have at least one profile extending to more than 4 half-luminosity radii. More than 90% of the galaxies are well resolved, having at least one profile where $R_e > 2\Gamma$, where Γ is the FWHM of the psf. More than 80% of the profiles have a global signal-to-noise ratio larger than 300. The extrapolation needed to derive total magnitudes is less than 10% for 80% of the fits. More than 80% of the galaxies have mean effective surface brightness larger than the observed sky brightness. In 90% of the profiles the estimate of the contamination of the sky by the galaxy light is less than 1%. Summarising, the extensive internal comparisons, together with Monte Carlo simulations (see Paper IV), show that we derive total magnitudes and half-luminosity radii to better than 0.15 mag and 25% respectively for 90% of our sample. In contrast, external comparisons show that data in the literature can be strongly affected by systematic errors due to large extrapolations, small radial range, sky subtraction errors, seeing effects, and the use of a simple $R^{1/4}$ fit. The resulting errors can easily amount to more than 0.5 mag in the total magnitudes and 50% in the half-luminosity radii. The errors on the combined quantity $FP = \log R_e - 0.3\langle SB_e\rangle$ which enters the Fundamental Plane equation remain however always smaller than 0.03 dex.

The galaxy type classification, based on all of the information available to us, shows that 31% of the sample objects, visually selected from photographic images to be of early type, are in fact spiral or barred galaxies. The 69% of galaxies classified as early-type can be subdivided into cD (8%), E (12% with a simple $R^{1/4}$ law best fit), and E/S0 (48% with a disk plus bulge best fit). The photographic diameters D_W measured in Paper I correlate with D_n diameters or, equivalently, with the Fundamental Plane quantity $FP = \log R_e - 0.3\langle SB_e\rangle$, with 23% scatter for the early-type sample.

Key words: galaxies: clusters - galaxies: elliptical and lenticular, cD - galaxies: fundamental parameters - galaxies: photometry - galaxies: distances and redshift - cosmology: large scale structure of Universe

1 INTRODUCTION

We, the EFAR collaboration, have recently completed a long-term project started in 1986, aimed at measuring the peculiar motions of 84 clusters in the two distant regions of Hercules-Corona Borealis and of Pisces-Cetus. A description of the cluster and galaxy sample, their redshift distribution and the selection function can be found in Wegner et al. (1996, hereafter Paper I). The goal of the project was to measure distances for an original list of 742 galaxies selected in these clusters, using the Fundamental Plane relation (Dressler et al. 1987, Djorgovski and Davis 1987), after further verification of their early-type morphology. The Fundamental Plane relation correlates the central velocity dispersion of elliptical and S0 galaxies to their half-luminosity radius and total magnitude and allows one to measure distances with about 15% (Jørgensen et al. 1996) precision. In order to measure the relevant photometric quantities entering the Fundamental Plane relation, 185 nights on 1 m class telescopes have been invested, of which 106 were useful: 80 nights for photoelectric photometry, of which 26 were usable, 105 of CCD imaging, of which 80 were usable, 18 for CCD photometry, and 62 nights for deep images. The photoelectric photometry collected in the R and in the B band for 352 galaxies has been published already by Colless et al. (1993, with nomenclature corrections given in Paper I). The central velocity dispersions and the line-strengths derived from the collected spectroscopic data are presented in Wegner et al. (1997, hereafter Paper II).

Here we present the final set of CCD photometry and deep imaging. We assess its quality by completing the comparison with our photoelectric measurements (started in Colless et al. 1993) and we derive the circularly averaged surface brightness and integrated magnitude profiles of the objects. By means of a fitting technique which incorporates seeing effects (see Saglia et al. 1993) and allows for two components ("disk + bulge", see Saglia et al. 1997, hereafter Paper IV), we compute the D_n radii, the half-luminosity radii, the total magnitudes of the galaxies and the parameters of the two components. We classify the galaxy types through inspection of the CCD images, the photometric profiles and additional colour and/or spectral information.

The set of observations is described in §2.1 and the standard data reduction in §2.2. The final comparison between our photoelectric and CCD photometry is summarised in §2.3. The precision of the indirect calibrations and the second- and third-order calibrations is investigated in §2.4 and 2.5. Comparisons of luminosity profiles with those of other authors are presented in §2.6. The results of analysing the surface brightness profiles are given in §3. The photometric parameters derived are presented in §3.1. The overall quality of the fits is discussed in §3.2 and the comparison of our derived parameters with those determined by other authors is given in §3.3. The galaxy type classification is presented in §3.4. The relation between the photometric parameters and the photographic diameters involved in the derivation of the galaxy selection functions (see Paper I) is discussed in §3.5. Conclusions are drawn in §4.

2 CCD PHOTOMETRY

2.1 Observations

The CCD data presented here were collected in 16 runs using 4 different telescopes with 12 different setups. Table 1 gives the log of these observations. Table 2 summarises the different setups and lists the properties of the detectors used. The different types of B and R filters used for all the runs are also listed. CCD frames were taken during a total of 80 nights (see Table 1 and Figure 8 for a detailed listing). Absolute photometry was assessed during 5 of these runs, for a total of 18 nights and 685 galaxy calibrations. Table 3 lists in detail the times of photometric conditions for each of these runs, giving also the number of standard star observations, the number of different stars observed, the rms residuals of these observations about the fitted photometric transformation (see §2.2) and the number of galaxies imaged in photometric conditions.

Standard data reduction procedures were employed throughout. In general, bias frames were taken at the beginning and end of each night. Sky flats were also taken each night, weather permitting, during evening and morning twilight. These were found to be superior to dome flats, which leave residual structure and gradients after flat-fielding.

During photometric nights standard stars, selected from Landolt's (1983, 1992) tables of UBVRI standards, were observed in B and R throughout each night following the technique described by Colless et al. (1993, see Baggley 1996 for more details). Galaxies were observed mostly in the Kron-Cousins system R band only. In this band the exposure times ranged from 150 to 300 seconds during photometric periods and up to 600-1200 seconds during non-photometric periods.

2.2 Data reduction

All CCD images of both standard stars and galaxies underwent the same basic reduction procedure. The images were first bias-subtracted, using the median of the ten or so bias images taken before or after each night's run offset to the mean level of the CCD's overscan strip. No correction for dark current was made, as this was negligible on all CCDs. Flat-field corrections for each filter were made by dividing each image by the normalised median of the twilight sky images. The resulting images had residual flat-field variations of less than 1% *rms* on the relevant scale. Cosmic ray hits were eliminated by means of running window median filtering. For the images obtained at the MG13 telescope with the RCA CCD, low sensitivity "stripes" running along the columns of the images had to be eliminated. These "stripes" resulted from a well known DC offset problem in the electronics. The correction was done using an IRAF* script which created a new image by fitting a straight line to each column after rejecting the objects. The median of each column was used to determine the relative offset between columns, which was then applied as an additive correction.

Most of the images were reduced using the IRAF package; the Starlink FIGARO package was used to reduce the CCD frames taken at the JKT telescope. Some of the images were reduced using the MIDAS package.

The procedure to derive instrumental magnitudes for the standard stars and to reduce these instrumental magnitudes to the standard BR photometric system has been described in detail by Colless et al. (1993) for runs 11 and 12 and by Baggley (1996) for the other photometric runs. The 11 photometric nights listed in Table 3 not published in Colless et al. (1993) reach photometric precisions similar to the ones previously achieved (see Baggley 1996).

Galaxy surface brightness profiles and integrated magnitude curves were derived also following Colless et al. (1993). Contaminating objects were removed by setting all the pixels in circular or square regions fully covering their images to a default value, indicating that the flux in these pixels is undetermined. The sky level was estimated using the mode of the pixel values in selected areas on the CCD frame, excluding the deleted regions and the area covered by the target galaxy. The centre of the galaxy's image was then established by centroiding over a small region about the peak of the light. The circularised surface brightness profile about this centre was computed by azimuthally averaging the flux at radii which are integer numbers of pixels, skipping deleted regions of the frame. This profile was then integrated out to the appropriate radii in order to compare CCD magnitudes with photoelectric photometry for one or more fixed apertures.

The procedure of excluding contaminating objects was adopted as a simple, robust, and model-independent method of deriving galaxy photometry. A more sophisticated decomposition approach might be more appropriate for galaxies in a dense environment, as some of the brightest cluster galaxies of the Postman & Lauer (1995) sample. However, the large majority of EFAR galaxies do not have close companions. In 86% of the cases no galaxy can be found in a circle of 1 arcmin diameter, in 64% of the cases in a circle of 2 arcmin diameter. Only two galaxies have 3 companions at distances smaller than 30 arcsec, and only two galaxies have 5 companions at distances smaller than 1 arcmin. Therefore, since the mean half-luminosity radius R_e of the EFAR galaxies is 6.9 arcsec (see §3.1), most of the objects can be considered "isolated" and do not suffer from light contamination from nearby companions.

The pixel scales listed in Table 2 were computed by considering all of the images which contained more than one program galaxy and by finding the offset in pixels between these objects. The corresponding offsets in arcsec were derived from the coordinates, which were determined using the GSSS (Guide Star Selection System) Astrometric Support Package (GASP) of the Space Telescope Science Institute and appear to have an accuracy of $0.5''$ (see Paper I). The typical precision in the scales is 0.005 arcsec/pixel. The scales compare well with the nominal values for each telescope, differing at the 1% level.

Isophote shape analysis was also performed, deriving elliptical isophote surface brightnesses, ellipticity and position angle profiles using the isophotal shape algorithm described by Bender & Möllenhoff (1987). However, we discovered that a relevant number of EFAR galaxies are too small or too faint for this analysis. In general, the circularised profiles are of superior quality and extend to larger radii. Figures 1, (a) and (b), show the distribution of the mean ellipticities inside R_e of the

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analysed galaxies: 95% of the sample has mean ellipticities $1-b/a$, where a and b are the semimajor and semiminor axis, less than 0.4, with a median value of 0.2. In fact, the procedure followed when selecting the sample (described in Paper I) systematically avoided to pick up highly flatten systems, in an attempt to reduce the contamination by spiral galaxies. Figure 1 (c) demonstrates that the differences between the curve of growths derived following circular apertures ($mag_c(<R)$) or following elliptical isophotal apertures ($mag_e(<R=\sqrt{ab})$) are minimal ($|\Delta mag|<0.03$) for the typical ellipticity profile of our galaxies (Fig. 1 (d); the galaxy GIN=001 is shown, where GIN is the Galaxy Identification Number given in Paper I). In addition, Paper IV shows that fitting circularised profiles does not bias the resulting photometric parameters, if the ellipticity of the galaxy is not larger than 0.4. Therefore, only circularised profiles will be considered here. A future paper will discuss the results of the isophote shape analysis for the subset of bright and large EFAR galaxies.

Instrumental CCD surface brightness and magnitudes profiles were transformed to the standard system using one or more of the following methods.

1) Direct CCD calibration was used when the image was taken under photometric conditions. The extinction coefficient, colour term and overall zero-point for the night were derived. A secular zero-point correction was also applied, as interpolated from the corrections derived from the two groups of stars that bracketed the galaxy observation. As only R-band images were obtained for most of the galaxies, we assumed a (B-R) colour of 1.7 in all cases. Colless et al. (1993) show that the typical error produced by this assumption is 0.001, and the maximum possible for a single galaxy 0.007 mag. Images taken under non-photometric conditions of objects having (at least) one direct CCD calibration were calibrated by matching the magnitudes inside a fiducial aperture (typically 14.95 arcsec radius) and taking into account the optimal sky corrections derived in §3.2. This approach mimics the procedure used when only photoelectric calibrations are available (see below). Equivalent results are obtained if the scaling constants determined from the fits of §3.2 (see also Paper IV) are used to perform the calibration.

2) Direct PE calibration was used when one or more photoelectric measurements were available (see Table 6 of Colless et al. 1993). The zero point was computed from the instrumental CCD magnitude with the photoelectric aperture, taking into account the optimal sky corrections derived in §3.2.

3) Indirect CCD calibration was used for galaxies on the same CCD frame as another galaxy having a CCD calibrated image. The zero point was computed following the procedure described in (1).

4) Indirect PE calibration was used for galaxies on the same CCD frame as another galaxy having a photoelectric measurement. The zero point was computed as in (2).

5) Cross-calibration. Images taken under non-photometric conditions of galaxies having zero-points from 3) or 4) were calibrated by requiring that the magnitude inside some appropriate aperture matched the one measured in (3) or (4), following the procedure described in (1).

Figure 2 summarises the status of the data. We collected 2846 profiles for a total of 776 galaxies, with 87% of the galaxies having more than 1 profile. For six program galaxies (GIN=42, 265, 309, 342, 434, 608) and six of the standard galaxies (GIN=780, 796, 797, 798, 800, 801) listed in Table 3 of Paper I no data were collected. Only 27% of the galaxies were observed with one telescope, 47% with two telescopes, 24% with three telescopes and 13% with all four telescopes. We calibrated a total of 674 objects using methods (1) to (4), for a total of 1286 calibrations, with 43% of the galaxies having repeat calibrations; 303 galaxies were calibrated by method (1) only, 102 galaxies by method (2), 238 by both methods (1) and (2), 31 galaxies by methods (3) and (4).

For the remaining 102 galaxies none of the calibrations (1)-(4) was possible. For 79 of these we derived a second-order calibration by considering the calibrations of the CCD frames of galaxies of the *same cluster* which were taken as near as possible in time. For 17 galaxies a third-order calibration was derived by considering the calibrations of the CCD frames of galaxies which were taken as near as possible in time. Finally, for 6 galaxies none of the methods described above gave a calibration. These galaxies were observed only once on the 26 June 1992. During this night Landolt stars showed photometric variations larger than 20%, so that the photometric calibration used here is only indicative.

2.3 Comparison of photoelectric and CCD photometry

Colless et al. (1993) have already presented the R-band CCD observations for 95 program galaxies, placing these on a BR photometric system for photoelectric and CCD photometry, with a common zero-point good to better than 1 percent and rms precision of both photoelectric and CCD R magnitudes of 2-3 per cent. Here we extend the comparison to the entire sample of galaxies and assess our conclusions.

Figure 3 shows the temporal variation in R_{CCD} on each of the photometric nights of Table 3, by displaying the 361 differences $R^i_{CCD}-R_{PE}$ (crosses, similar to Figure 3 of Colless et al. 1993), together with the 288 differences $R^i_{CCD}-R^j_{CCD}$ between the magnitudes inside a 14-15 arcsec aperture measured during Runs i and j (see coding described in the figure caption). Note that we have excluded from the comparisons the PE magnitudes of the galaxies GIN=10, 24, 177, 266, 687, 695, 697, 733. The PE magnitudes of the galaxies GIN=10 and 24 deviate largely from the CCD magnitudes and are therefore discarded. The photoelectric data of the remaining galaxies are systematically brighter than the CCD magnitudes, because a disturbing star is present in the photoelectric aperture. For the same reason we discarded the PE magnitude with the 39.5

arcsec aperture of galaxy GIN=454, keeping the 29.9 arcsec aperture datapoint. Some nights had significant (at a level larger than 3σ) mean shifts, which have been removed from the data. In particular, the final sample confirmed the significance of the mean differences noted by Colless et al. (1993) for the 90.10.17 and 91.05.09 nights. In addition, the larger sample together with the revision of some galaxy profiles taken during the 90.10.15 revealed the shift applied to this night. The rather large shifts observed during Run 14 may be partially due to the fact that the standard stars were observed out of focus to avoid saturating the CCD. In addition, the photometry had to contend with changes in nightly transparency owing to high altitude dust produced by the Mount Pinatubo eruption. The final dataset has a common zero-point to better than 0.01 mag.

The resulting distribution of the differences ΔR ($R^i_{CCD} - R^j_{CCD}$ and $R_{CCD} - R_{PE}$) is shown in Figure 4. The full line shows all of the available 505 comparisons and gives a mean $< \Delta R >= +0.003$ and a standard deviation about the mean $\sigma_{\Delta R} = 0.035$. The histogram obtained for the 361 CCD-PE comparisons (dotted line) gives $< \Delta R >= +0.002$, $\sigma_{\Delta R} = 0.038$; that for the CCD intercomparisons (dashed line, 144 comparisons) $< \Delta R >= +0.006$ and $\sigma_{\Delta R} = 0.026$. Colless et al. (1993) obtained similar results for Run 11 and 12. The conclusion that the precision of the CCD magnitudes is 0.02-0.03 *per observation* is therefore confirmed.

The trends Colless et al. (1993) found are confirmed for the entire sample of $R_{CCD} - R_{PE}$ comparisons. Figure 5 is the analog of Figure 4 of Colless et al. (1993) for Runs 6, 14 and 16. Fig. 5a confirms that the fainter galaxies ($14 < R < 15$) have a scatter $\sigma_{\Delta R} = 0.038$ mag, close to the value of the sample as a whole, while brighter ($R < 14$) galaxies show significantly less scatter: $\sigma_{\Delta R} = 0.031$. A similar, but weaker, trend is found when considering the CCD-CCD comparison. Neither the mean nor the scatter of the differences varies with the galaxy's B-R colour (Fig. 5b), the airmass of the observations (Fig. 5c), or the aperture size used to make the measurement (Fig. 5d).

Figures 3-5 are constructed using the sky values as derived from the CCD frames for consistency with Colless et al. (1993) when comparing to photoelectric magnitudes, and the sky corrections computed by the fitting scheme described below when intercomparing CCD data. The same mean zero-point corrections and scatter are derived if the sky corrections to the CCD data are applied also when performing the comparison with photoelectric data.

Galaxies having photoelectric magnitudes measured with apertures of different sizes provide a further consistency check. The CCD curve of growth allows the comparison. The rms scatter derived from the 31 pairs is 0.042 mag, in agreement with that found above. An additional pair (GIN=303, apertures 29.9$''$ and 60.2$''$, see Colless et al. 1993), gives a 0.65 mag difference. The 29.9$''$ data point is the average of two consistent values. Therefore in the following we discard the 60.2$''$ magnitude (but see §2.5).

A further detailed check of the precision of the CCD photometry is given in Figure 6, showing magnitude difference profiles. There are 119 galaxies for which more than one CCD profile has been derived under photometric conditions, for a total of 144 profile pairs. The left panels show the differences obtained without sky correction. Sky subtraction errors of order 1-3% can easily generate differences of 0.1-0.2 mags between the central and the outer regions. The right side of the figure shows that the sky corrections computed from the fits eliminate this problem and reduce the overall scatter from 0.049 mag to 0.029 mag, which compares well with the result derived from the comparison with photoelectric measurements.

2.4 Precision of the indirect calibration

The precision of the indirect calibrations (3) and (4) described in §2.2 was estimated by calibrating galaxies with direct calibrations (1) or (2) with the same method, and comparing the results. Figure 7 shows the histogram of the residuals, when the sky subtraction corrections are applied. Galaxies observed with sky values larger than 4000 counts per pixel have been excluded, because the bright sky deteriorates their quality. The precision achieved is $\sigma = 0.057$ mag, which is somewhat worse than that of methods (1) and (2), due to the additional uncertainty of the second sky subtraction.

2.5 Precision of second- and third-order calibration

The precision of the second and third-order calibration is evaluated by monitoring the variations of the calibrated value of the sky as a function of time. Figure 8 shows that during most of the nights considered for these calibrations, the sky variations are slow enough so that calibrations good to 0.1-0.2 mag are achieved. Images taken in very cloudy conditions show much stronger variations on a shorter time scale. The calibrations derived in these cases are not better than 0.2 mag.

Inspection of Figure 8 reveals also some anomalous data points. Galaxy GIN=106, observed on 87.10.25, has photoelectric aperture magnitudes nearly 1 mag brighter than the other objects in the cluster (see Colless et al. 1993), indicating a possible misidentification of the photoelectric observations. Galaxy GIN=303, observed on 87.03.23 and 88.06.10, has been discussed in Sect. 2.3. The 60.2 arcsec aperture would give sky values in better agreement with the sky temporal evolution. Galaxy GIN=500, observed on 88.06.13, is somewhat brighter than the other objects of its cluster, indicating a possible misidentification of the photoelectric observations.

2.6 Luminosity profiles: External Comparisons

Postman and Lauer (1995, hereafter PL) obtained R band CCD photometry for a sample of 119 galaxies, 30 of which we have observed. Their Table 5 summarises the comparison with the photoelectric data for 21 galaxies of Colless et al. (1993). Here we complete the comparison by adding 9 galaxies to that list and by considering the integrated magnitude profiles.

Figure 9 plots the PL-EFAR differences galaxy by galaxy. The EFAR curves of growth include the optimal sky corrections computed in §3.2. Each box gives the Galaxy Identification Number (GIN) of every galaxy (see Paper I) and the symbols refer to the different kinds of photometric calibrations used (see Figure Caption). The differences between the integrated magnitudes in this paper and the ones reported from PL are plotted as a full line connecting the points belonging to the same CCD. For two galaxies (GIN 579 and 681) a zero point shift (value written in the box) has been subtracted to this difference to be able to display the data. The comparison shows that the two sets of data globally compare well, with typical differences inside 20 arcsec apertures less than 0.05 mag. There are 4 galaxies with shifts larger than 0.1 mag, GIN 001, 078, 579 and 681. They were observed during Runs 2 and 4 of PL. Galaxies 078 and 579 have double nuclei, and since our photometry is brighter than the one of PL, the difference could be due to the decomposition technique PL applied. In any case, our CCD photometry for 078 is confirmed by one PE data point, and galaxy 579 was observed on May 13^{th}, 1991, where the comparison with PE measurements shows very small scatter (see Colless et al. 1993). The remaining two discrepant cases (GIN 001 and 681), where our PE and CCD photometry agree well, suggest that the problem lies with PL's photometry. PL note that when these two discrepant cases are omitted, their photometry appears brighter by -0.026 mag on the mean than our photoelectric data.

Gradients in the differences as a function of radius are present in 18 of the galaxies plotted, with our data becoming progressively fainter than PL's magnitudes. Stronger gradients are seen if no sky corrections are included in our profiles. The gradients disappear if a negative sky subtraction correction of 1-2% is allowed, pointing to an overestimation of our sky values, or to an underestimation of PL's sky values, or a combination of the two possibilities. The large size of these galaxies may suggest that our sky values have been overestimated due to galaxy light contamination. However, based on the fits in §3.2 (Fig. 13(b)), we estimate a maximum contamination of our profiles of 0.5%. The -0.026 mag mean shift between PL data and our photoelectric aperture magnitudes (which should be very little affected by sky subtraction errors) can be explained by a 1-2% underestimation of PL's sky values.

For eight galaxies (GIN 065, 108, 209, 487, 559, 562, 663, 738) photoelectric photometry in the B band is available in the literature (Burstein et al. 1987). These data are not directly comparable to our B photoelectric photometry (see Colless et al. 1993), since the apertures used are different. However, we can assume that the (B-R) radial gradients are small and use the R band CCD photometry presented here to match the apertures. The absolute residuals are always smaller than 0.1 mag. The R aperture magnitudes available for galaxies 108 and 663 are also consistent with our calibration.

3 SURFACE BRIGHTNESS PROFILES

3.1 Photometric parameters

Total magnitudes m_T, half-luminosity radii R_e and D_n diameters are derived from the surface brightness profiles of 762 program galaxies following the method extensively described and tested in Paper IV. The algorithm consists of three steps. (1) The available multiple profiles of a given object are optimally combined, taking into account differences in sky subtraction and scaling factors. (2) A seeing-convolved (using the $\gamma = 1.6$ psf, see Paper IV), $R^{1/4}$-plus-exponential profile is fitted to the combined data, with the option of simultaneously determining the optimal sky correction. A non-linear searching strategy minimises the weighted sum of the squared magnitude differences between the galaxy surface brightness profiles and the model. Statistical weights are applied using the gains and the readout noise parameters given in Table 2. The model normalisation is determined by minimising the weighted sum of the squared linear differences between the galaxy profiles and the model. An optimal sky correction can also be computed as the value of the additive constant that minimises further this sum. Alternatively, the sky correction is set so that the mean (over the available galaxy profiles) percentage sky error is zero. A 3σ test determines the need of a second component against the case of a simple $R^{1/4}$ or exponential fit. The fitting program outputs the parameters of the fitted components (the scale and effective surface brightness of the $R^{1/4}$ component, R_{eB} and μ_{eB}, the scale and central surface brightness of the exponential component h and μ_0), the seeing values and the sky corrections.

(3) A quality parameter Q is assigned to the resulting fits, taking into account: (1) the amount of extrapolation involved, (2) the size of the sky correction applied, (3) the goodness of the fit as measured by the reduced χ^2, (4) the radial extent of the fit, (5) the global signal-to-noise ratio of the data, (6) the spatial resolution of the profiles relative to the size of the galaxy, and (7) the average surface brightness of the galaxy relative to that of the sky. The relative importance of these quantities to the overall quality of the fit is described exhaustively in Paper IV. Fits with $Q = 1$ give total magnitudes and R_e to better than 0.05 and 10%, fits with $Q = 2$ to better than 0.15 and 25% respectively, fits with $Q = 3$ may have systematic errors

larger than 0.15 and 25% respectively. The errors on the combined Fundamental Plane quantity $FP = \log R_e - 0.3\langle SB_e \rangle$ or on $\log D_n$ (see definition below) are ≤ 0.005 for $Q = 1$, ≤ 0.01 for $Q = 2$ and ≤ 0.03 for $Q = 3$. Paper IV demonstrates that sky subtraction errors of the order of 1% can introduce large systematic biases on magnitudes and scalelengths if not accounted for. Therefore the fits presented below are performed using the sky correction algorithm as a default. However some of the fits obtained by setting the mean percentage sky error to zero give better reduced χ^2 and are therefore preferred. In addition, some of the fits derived with the sky correction algorithm would involve extrapolations larger than 30%. In these cases also the fits obtained by setting the mean (over all profiles of a given galaxy) percentage sky error to zero are preferred, if they involve a smaller extrapolation. Finally, all of the resulting fits were scrutinised visually, revising the assigned fits in a small number of cases. As a result, one of the 6 possible fit types is assigned to each galaxy: $R^{1/4}$ only fit with or without sky correction (B, NB, where B indicates Bulge), exponential only fit with or without sky correction (D, ND, where D indicates Disk), bulge plus disk fit with or without sky correction (BD, NBD).

There are several advantages in using the $R^{1/4}$ plus exponential model as a fitting function to determine the photometric parameters of the EFAR galaxies. The model is flexible enough to give reasonably good fits to the large variety of luminosity profiles that EFAR galaxies show. It provides reasonably accurate parameters, because it does not involve large amounts of extrapolation. In addition, it helps in the galaxy type classification (see below). We distinguish three types of fits: (i) fits to galaxies with cores, (ii) fits to cD galaxies, (iii) fits to early-type and spiral galaxies. In the first two cases, the exponential component is used to fit either the large central core or the extended profile of the galaxy and does not indicate the presence of a physical disk. In the third case we argue that a physical disk is indeed detected. Paper IV shows that the parameters of bulge plus disk systems can be determined by our fitting algorithm, if the disk inclination is smaller than 60^0. Figure 1 shows that 95% of the EFAR galaxies have mean ellipticities less that 0.4. Galaxies with luminous disks inclined more than 60^0 therefore should be nearly absent from our sample.

Table 4 summarises the photometric parameters derived from the fits to the R band CCD frames, together with the (B-R) colours and the photometric corrections. Column (1) gives the Galaxy Identification Number (GIN), as in Paper I. Column (2) gives the galaxy names, as in Paper I. Column (3) gives the galaxy morphological type, as determined in §3.4.

Column (4) consists of 8 numbers, giving the number of images available (I), the number of photoelectric calibrations (P, method (2) of §2.2, see also Colless et al. 1993), the number of CCD calibrations (C, method (1) of §2.2), the number of indirect calibrations, coming from photoelectric (P, method (4) of §2.2) or CCD (C, method (3) of §2.2) calibrations, the number of second or third order calibrations (S or T, see §2.2), the number of bad calibrations (B, see §2.2).

Column (5) specifies the type of fit performed, with B indicating a simple bulge ($R^{1/4}$) fit, D a simple disk (exponential) fit and DB a disk plus bulge fit. The presence of an N (no sky correction) indicates that the mean percentage sky correction has been set to zero (see Eq. (6) of Paper IV). If no N is present, the sky correction algorithm (see Eq. (12) of Paper IV) is applied. The symbol $*$ marks the two-component fits where the fitted exponential component should not be interpreted as a physical disk. This happens for cD galaxies and galaxies with cores. Column (6) gives the quality parameters of the fits. Following the definitions of Table 1 of Paper IV, we list the values of the extrapolation parameter Q_E (E), the χ^2 parameter Q_{χ^2} (C), the radial extent parameter Q_{max} (R), the seeing parameter Q_Γ (F for FWHM), the signal-to-noise ratio parameter $Q_{S/N}$ (N), the sky correction parameter $Q_{\delta \mathrm{Sky}}$ (S), the sky parameter Q_{Sky} (B for bad sky) and the global quality parameter Q. The parameter Q correlates with the precision of the photometric parameters derived from the fits (see above). In five cases (GIN=175, 182, 338, 527, 657) the value of Q has been downgraded, because the comparison of BD and NBD fits showed differences in the photometric parameters larger than the maximum predicted value.

Columns (7) and (8) give the final zero-point calibration as the R-band magnitude (8) inside the aperture of radius R_{ap} (7). For uniformity with the photoelectric data of Colless et al. (1993) we set $R_{ap} = 14.95$ arcsec or the largest radius of the available CCD profiles. Column (8) is determined using the average of the available calibrations; its rms error is given in column (15).

Column (9) gives the D_n diameter in arcsec. The D_n diameter is the diameter of the aperture enclosing a mean *fitted* R surface brightness of 20.5 mag arcsec^{-2}, corrected for galactic absorption, K_R correction and cosmological dimming (see Columns (17), (18) and (20)). The surface brightness level of 20.5 R mag arcsec^{-2} corresponds to an ≈ 1.5 magnitudes fainter level in the blue band than the one used by Faber et al. (1988). This allows us to derive larger diameters and therefore minimise the seeing corrections. As a test, we derived D_n diameters for a surface brightness of 19.25 R and 20 mag arcsec^{-2}. They have median values of 8.8 arcsec and 14.4 arcsec respectively, with 20% and 5% of the objects with $D_n \leq 6$ arcsec. Column (10) gives the D_n scatter in arcsec due to the uncertainty in the photometric zero point. The scatter is computed as the rms of the D_n diameters derived from the k available photometric zero points (see Column (4)). The photometric error on the given data point is smaller by a factor $\sqrt{k}$. The photometric scatter does not include the systematic errors of the fits, which are coded by the quality parameter Q (see above).

Column (11) gives the half-luminosity radius R_e in arcsec. Column (12) gives the average effective surface brightness (or average surface brightness inside R_e) $\langle SB_e \rangle$ † in mag arcsec^{-2}, corrected for galactic absorption, K_R correction and cosmological dimming (see Columns (17), (18) and (20)). Its photometric error is the same as in Column (15). Column (13) gives the total R magnitude m_T, corrected for the galactic absorption and K_R correction (Column (17) and (18)). Its photometric error is the same as in Column (15). Column (14) gives the effective surface brightness SB_e (or surface brightness at R_e) in mag arcsec^{-2}, corrected for galactic absorption, K_R correction and cosmological dimming (see Columns (17), (18) and (20)); column (15) gives its photometric scatter. The photometric scatter is due to the uncertainties on the photometric zero point, and is computed as the rms of the k available photometric calibrations (see Column (4)). The error on the given data point is smaller by a factor $\sqrt{k}$. The photometric scatter does not include the systematic errors of the fits, which are coded by the quality parameter Q (see above).

Column (16) gives the $(B-R)$ colours derived from the photoelectric data listed by Colless et al. (1993) and corrected for galactic absorption (Column (17), $A_B = 1.708 A_R$, Burstein & Heiles 1982, 1984) and K_R and K_B corrections (Columns (18) and (19)).

Column (17) lists the R-band absorption corrections A_R as computed in Paper I. Column (18) lists the K_R correction in magnitudes, computed following King & Ellis (1985) as $1.00 \times z_{gal}$ for early-type galaxies (cD, E and S0/SB0, plus galaxies with double cores classified as DB), and as $0.32 \times z_{gal}$ for late-types. Here z_{gal} is the galaxy redshift as given in Paper II. Column (19) lists the K_B corrections in magnitudes, computed as $K_B = 5 \times z_{gal}$ for early-type, and as $K_B = 3.9 \times z_{gal}$ for late-type galaxies. If no redshift was measured, we used the cluster redshift z_{clus} as given in Paper II for both Columns (18) and (19). Note that very late-type spirals ($\geq$Sb) are expected to have smaller K_R and K_B corrections. However, we opted not to do a finer morphological classification owing to the use of just R band data, seeing of typically $1-2''$, and the large distances of many of these galaxies. In any case, very late-type spirals should be a very small fraction of the spirals in the sample (see Paper I). Column (20) gives the cosmological dimming for surface brightness (in magnitudes) as $K_{SB} = 2.5 \times \log[(1+z_{clus})^4]$, where we use the redshift of the clusters, z_{clus}, to estimate cosmological distances. The symbol $*$ flags the galaxies where no redshift is available.

The last six columns of Table 4 list the parameters of the bulge and disk components, if the two-component fit has been chosen. Column (21) gives the ratio h/R_{eB} of the exponential scale length h of the disk component to the half-luminosity radius R_{eB} of the bulge component. Column (22) gives the ratio of the total luminosity in the exponential and the $R^{1/4}$ component D/B (for "disk-to-bulge" ratio). Column (23) lists R_{eB} in arcsec. Column (24) gives the surface brightness at R_{eB} of the bulge μ_{eB} in mag arcsec^{-2}, corrected for galactic absorption, K_R correction and cosmological dimming (see Columns (17), (18) and (20)). Column (25) gives h in arcsec. Column (26) gives the central surface brightness of the disk μ_0 in mag arcsec^{-2}, corrected for galactic absorption, K_R correction and cosmological dimming (see Columns (17), (18) and (20)). The photometric uncertainties of the parameters of the decomposition are of the same order as the ones given in Column (15). The systematic errors are usually much larger and are coded by the quality parameter Q (see Paper IV for a detailed discussion). The notes at the end of the Table discuss the most peculiar or problematic cases.

Figure 10 shows the distributions of the photometric parameters and the photometric precision achieved. Only galaxies with photometric calibrations derived using methods (1) to (4) (see §2.2) are considered. The diameters D_n span the range 4.8-90 arcsec, with $\langle \log D_n \rangle = 1.30$ or 20 arcsec. The effective radii R_e span the range 1.6-71.2 arcsec, with $\langle \log R_e \rangle = 0.84$ or 6.9 arcsec. The total magnitudes m_T span the range 10.57-15.97 mag, with a mean of 13.85 mag. The effective surface brightnesses $\langle SB_e \rangle$ span the range 17.78-22.35 mag arcsec^{-2} with a mean of 19.89 mag arcsec^{-2}. The mean photometric precision of D_n diameters, magnitudes and surface brightnesses where only one calibration is available is 1.4%, 0.026 mag, and 0.026 mag arcsec^{-2} respectively. The mean photometric precision of D_n diameters, magnitudes and surface brightnesses taking into account multiple calibrations are 0.9%, 0.017 mag and 0.017 mag arcsec^{-2} respectively.

Figure 11 shows the resulting fits. Two plots are shown for each galaxy. The upper panel shows the calibrated surface brightness profile (small dots) together with the fitted bulge and/or disk profiles (full lines) as a function of the 1/4 power of the distance from the centre in arcsec. The vertical full line at the top shows the derived value of R_e. The horizontal dashed line shows the position corresponding to 1% of the sky as measured on the most extended profile available. On the bottom left side of the plot the galaxy name (first line), its GIN and CAN (Cluster Assignation Number, see Paper II) numbers (second line), the value of R_e in arcsec (third line) and the total magnitude (fourth line) are given, together with a code summarising Column (4) of Table 4. The code gives the number of different profiles that have been fitted (Column (4)I of Table 4), the number of different types of photometric calibrations (with P and C indicating the second and third entry of Column (4) of Table 4, IP and IC the fourth and fifth, S and T the sixth and seventh, and B the eighth) and the quality parameter Q of the fit (last digit of Column (6)). On the top right of the plot the galaxy type (first line), the h/R_{eB} ratio (second line, 0 if a one component fit was selected, Column (21) of Table 4), the D/B ratio (third line, 0 if a one component fit was selected, Column

† Some words are needed to explain nomenclature. Burstein et al. (1987) and the 7 Samurai's papers indicate this quantity with SB_e, but omit the K_{SB} corrections; Jørgensen et al. (1995) with $\langle \mu \rangle_e$; Lucey et al. (1991) with μ_e; de Vaucouleurs et al. (1991) with m'_e.

(22) of Table 4) and the fit type are given (fourth line, Column (5) of Table 4). In the bottom right corner the reduced χ^2 of the fit is given.

The second plot gives the surface brightness magnitude differences $\Delta\mu(R) = \mu_{obs}(R) - \mu_{fit}(R)$ (dots, scale -0.2 to 0.2 mag arcsec^{-2}) and the integrated magnitude differences $\Delta mag(R) = mag_{obs}(< R) - mag_{fit}(< R)$ (full lines, scale -0.1 to 0.1 mag). The residuals in surface brightness are usually less than 0.05 mag arcsec^{-2} and rarely larger than 0.1. The residuals in integrated magnitudes are usually less than 0.03 mag and rarely larger than 0.05 mag. Larger residuals are observed sometimes in the outer, noisy regions of the galaxies or inside the seeing disk. The fits are uniformly good over a very large radial range, typically $2'' < R < 4R_e$, but often also out to $8 - 10R_e$. However, systematic residuals are still observed for some galaxies, in particular spirals where strong spiral arms appear in the circularly averaged profiles.

Figure 12 (see also §3.2) shows that ≈90% of the fits have reduced χ^2 larger than 2. The residuals observed are therefore highly significant statistically. However, if we exclude the case of spiral arms, they mostly take the form of *small-scale* deviations from the fits. In this sense, the fits are a good representation of the large-scale structure of the light profile while being an inadequate description of the small-scale structure. The consequences of this result will be discussed in a future paper.

3.2 Quality of the fits

Figure 12 summarises the global properties of the fits. It shows the cumulative distributions of (a) the quality parameter Q, (b) the disk-to-bulge ratio, (c) the type of sky correction applied, (d) the average (over the galaxy profiles) sky correction, (e) the rms spread of the percentage sky corrections applied to the profiles of each single galaxy, (f) the logarithm of the reduced χ^2 of the fit, (g) the improvement of χ^2, measured in units of $\sigma = \sqrt{2/N_{BD}^{free}}$, when a two-component fit is preferred to an $R^{1/4}$ fit, (h) the radial extent of the profiles in units of R_e, (i) the half-luminosity radius in units of the FWHM of the seeing psf, (l) the logarithm of the total signal-to-noise ratio of the profiles, (m) the amount of extrapolation involved in the derivation of the total magnitudes, (n) the ratio between the effective surface brightness of the galaxy and the one of the sky, (o) the percentage galaxy light contamination to the sky value.

Simple $R^{1/4}$ fits (plotted with $\log D/B = -3$) are only 14% of the total (110 galaxies out of 762), simple exponential fits (plotted with $\log D/B = 3$) are ≈ 1% of the total (9 galaxies out of 762). The improvement in the reduced χ^2 obtained in the 85% of the cases when a two-component fit is selected is highly significant. When compared to the $R^{1/4}$ fits, the two-component fits are better at the 16σ level as a median value, and at least the 5σ level in 90% of the cases. The significance is one order of magnitude larger when comparing exponential fits to two-component fits. The sky-fitting algorithm solution is used in 60% of the cases; an absolute mean percentage sky correction larger than 3% has been applied in only 1.5% of the fits. The spread in sky values measured from the different profiles of the same object is less than 1% in 85% of the cases. In 80% of the fits a reduced χ^2 less than 12 (based on the simulations that define Q_{χ^2}, see Table 1 of Paper IV) is obtained. More than 90% of the galaxies have at least one profile extending to more than 4 half-luminosity radii. More than 90% of the galaxies are well resolved, having at least one profile where $R_e > 2\Gamma$, where Γ is the FWHM of the psf. More than 80% of the profiles have a global signal-to-noise ratio larger than 300. The extrapolation needed to derive total magnitudes is less than 10% for 80% of the fits. More than 80% of the galaxies have mean effective surface brightness larger than the observed sky brightness. In 90% of the profiles the estimate of the contamination for the sky by the galaxy light is less than 1%. This estimate is computed as the average surface brightness in the annulus with radii R_{max} and $2R_{max}$ (where R_{max} is the radial extent of the profiles), as extrapolated from the fit, normalised to the sky value. Paper IV shows that this quantity is a robust upper limit to the actual galaxy light contamination of the sky values, measured as described in §2.2. Summarising all the above, 90% of the fits have a quality parameter $Q \leq 2$, with a core subset of 16% of the fits meeting all of the excellence criteria described in Paper IV.

The global quality of the fits is illustrated further in Figure 13, where we use frames with more than one object to assess how well we can determine the sky level and the seeing values. In panel (a) we show the cumulative distribution of the percentage rms values of the corrected sky levels for CCD images containing multiple objects of fit quality $Q = 1$ (full line), $Q \leq 2$ (dotted line) and $Q \leq 3$ fits (dashed lines). The figure shows that $Q = 1$ fits pin down the sky corrections to less than 0.5% for 80% of the objects. When $Q \geq 2$ fits are included, the precision achieved for 80% of the objects is 1%. Panel (b) shows the correlation between the estimated maximum percentage sky contamination due to galaxy light and the applied mean percentage sky correction (if different from zero). In Paper IV we tested that the estimated sky contamination due to galaxy light overestimates the actual contamination by at least a factor two, so that the points of Panel (b) should lie above the drawn line. We find here that the sky corrections applied correlate with the estimated percentage sky contamination due to galaxy light and are larger than the predicted maximum value for some of the $Q = 2$ and $Q = 3$ fits. On one hand this might reflect the fact that our estimated upper limit of the sky contamination does not take into account the additional contribution of possible nearby objects in the cluster (see §2.2). On the other hand, some of the fits, especially the ones with $Q = 3$, might fall in the category described in §3.8 of Paper IV, where the sky correction is used to compensate systematic differences between the fitting function and the data. Panel (c) shows the cumulative distribution of the rms of the seeing values Γ normalised to their mean values, for CCD images which contain more than one program galaxy for fit quality $Q = 1$ (full line), $Q \leq 2$ (dotted line) and $Q \leq 3$ fits (dashed lines). For 80% of the objects the precision of the seeing estimates is better than 10% for $Q = 1$ and 15% for $Q \geq 2$. This result supports the conclusion in Paper IV using Monte Carlo simulations, that the seeing values derived from the fits match the actual ones of the observations well and depend only mildly on the details of the profiles. Seeing values derived from fits to star profiles show the same kind of agreement. Finally, plot (d) shows the cumulative distribution of the (absolute) differences in magnitude between the relative normalisations of the multiple profiles of a single galaxy as computed by the optimal combination algorithm and as resulting from the fitting procedure (see Equations 2 and 10 of Paper IV). The differences are smaller than 0.05 mag for 80% of the profiles.

3.3 Photometric Parameters: External Comparisons

Only a small fraction of the galaxies observed here have independently measured photometric parameters. Burstein et al. (1987) give total magnitudes and half-luminosity radii in the B band, fitting the $R^{1/4}$ law without seeing corrections, to photoelectric aperture magnitudes for 13 program galaxies, 16 Coma cluster galaxies (and 11 standard galaxies which we do not consider here). Jørgensen et al. (1994, 1995) have determined R_e and total magnitudes in the Gunn r band for 20 of the Coma Cluster galaxies observed here. They fit the curve of growth derived from CCD frames with the $R^{1/4}$ law; their 1995 paper revised the results of 1994 by incorporating seeing effects. Graham (1996) derives total magnitudes and half-luminosity radii of the 30 galaxies of Fig. 9, by fitting the curves of growth of Postman and Lauer (1995) galaxies using the $R^{1/4}$ law. Lucey et al. (1991) have determined half-luminosity radii and average surface brightnesses for 6 galaxies in the cluster Abell 2634, and 14 galaxies in the Coma cluster, by fitting the curve of growth obtained from CCD frames in the V band with the $R^{1/4}$ law, including a seeing correction (see discussion in Saglia et al. 1993). Finally, Guzmán (1993) observed 7 galaxies in the cluster Abell 2199, 8 galaxies in Abell 2634, and 14 galaxies in the Coma cluster, deriving photometric parameters in the V band following the same procedure as Lucey et al. (1991). Figure 14 shows the result of the comparisons as a function of the disk-to-bulge ratio D/B and scale length h/R_{eB} ratios derived from the fits. Only galaxies with calibrations (1)-(4) (see §2.2) have been considered. Table 5 summarises the mean shifts and rms found in the comparisons.

Reasonable to good agreement is obtained with Burstein et al. (1987), Jørgensen et al. (1995), Lucey et al. (1993), and Guzmán (1993). After applying the appropriate zero-point shifts to account for the different passband, the total magnitudes show rms scatter of 0.13-0.19 mag, the half-luminosity radii of 0.09-0.13 dex, the effective averaged surface brightness of ≈ 0.4 mag arcsec^{-2}, and the quantity $FP = \log R_e - 0.3\langle SB_e\rangle$ of ≈ 0.02. The simulations performed in Paper IV show that the observed mean deviation and scatter are what is expected when photoelectric aperture magnitudes with a limited radial range, or CCD profiles are fitted using the $R^{1/4}$ law. The largest deviations appear when the fit involves a relatively luminous exponential component ($D/B \approx 0.7$). The rms values quoted by Jørgernsen et al. (1995) are somewhat smaller than the ones found here, when comparing their photometric parameters with previous results. This stems from the fact that the parameters compared there are all derived using the $R^{1/4}$ law as a fitting function of the curves of growth. The simulations of Paper IV show that the actual systematic errors are larger, of the order of the rms found here.

The Burstein et al. data for galaxy 105 (showing $\Delta m_T \approx -0.9$ and $\Delta \log R_e \approx 0.5$) are derived from two aperture magnitudes with apertures smaller than the derived effective diameter. This galaxy has been omitted from the Figure. Two galaxies showing a large zero point error, GIN=751 and GIN=723, have been excluded from the comparison with Lucey et al. (1993) and Guzmán respectively.

Larger systematic differences are seen in the comparison with Graham (1996). Graham's magnitudes are up to one magnitude brighter, his R_e up to a factor 2.5 larger than our results, and his $\langle SB_e\rangle$ up to 1.5 mag fainter. The differences in the combined quantity $FP = \log R_e - 0.3\langle SB_e\rangle$ are however small. The galaxies showing the largest deviation (GIN=001, $\Delta FP = -0.05$, GIN=078, $\Delta FP = -0.076$, GIN=681, $\Delta FP = -0.043$) are cases where the Postman & Lauer's calibrations are in doubt (see §2.6). These differences can be readily understood in the light of the simulations presented in Paper IV. The most severe bias comes from the use of pure $R^{1/4}$ fits: surface brightness profiles of cD galaxies (common in his sample of BCGs) deviate strongly from a de Vaucouleurs profile, as Graham et al. (1996) point out. Our fits address this problem by introducing a luminous and extended exponential component (see discussion in §3.1). As shown in Paper IV, this is equivalent to the use of $R^{1/n}$ profiles. Some of Graham's data points suffer also from other systematic effects described in Paper IV: the short radial range available to fit (most of the fitted profiles do not extend to more than twice the derived R_e), the resulting large extrapolations (typically $\geq 30\%$), the possible influence of sky subtraction errors (see Fig. 9), the small number of data-points fitted ($\approx 3-10$).

The comparison between the D_n diameters derived here and the literature values is complicated by the use of different bands and different surface brightness levels to define D_n. Figure 15 shows that the differences $\log D_n(Others) - \log D_n(EFAR)$ follow approximately what is expected for an $R^{1/4}$ law. Once this dependence has been subtracted, the mean shifts are ≤ 0.01 and the rms ≈ 0.01 dex, with larger values for the comparison with the 7 Samurai data. The galaxies GIN=579 (which has a double nucleus), GIN=487, 755, 763, 769, which show large residuals, have been excluded from the comparison.

3.4 Galaxy classification

The galaxies in our sample are classified as early-type (cD, E and S0s) or spirals of various type or barred galaxies on the basis of their morphological appearance, surface brightness profile shape and, possibly, colour or spectroscopic information. Early-type galaxies are classified as cD if they are the largest and brightest galaxies of their clusters and have $R_e > 10$ kpc. The remaining early-types are further classified into E and E/S0 types according to the results of the profile fit. Pure $R^{1/4}$ fits are classified as Es, $R^{1/4}$ plus exponential fits as E/S0. The D/B parameter (of the fits without the $*$ label, see §3.1) can be considered as regulating the continuum transition between the two types.

Of the 762 program galaxies fitted, three (GIN=171, 276, 358) appeared to be double (DB), 63 galaxies were classified cD (8%), 92 E (12%; note that an additional 2% of the objects, classified as cD, spiral or SB0, have pure $R^{1/4}$ fits), 368 E/S0 (48%), and 236 spirals or barred galaxies (31%). Thus there is a total of 523 early-type galaxies (69%). Figure 16 shows the distribution of galaxies according to their absolute total magnitude, $\log R_e$ in kpc, D/B ratio, h/R_{eB} ratio, $(B-R)$ colour and morphological type. Distances have been computed from the cluster redshifts using $H_0 = 50$ km/s/Mpc. $B-R$ colours (see Table 4) are available only for a subset of galaxies.

The objects classified as cD are indeed the most luminous and largest galaxies in the sample. The shallow surface brightness profile of cD galaxies is best fitted with the help of an exponential component which is both significant ($D/B > 0.2$ in 80% of the fits) and extended ($h/R_eB > 1$ in 70% of the fits). This result is consistent with the findings of Paper IV, where the $R^{1/n}$ profiles, which nicely fit the profiles of extended giant galaxies (D, cD, see Graham et al. 1996), are fit by means of an $R^{1/4}$ plus exponential law superposition. As discussed in §3.1, in Table 4 and Figure 11 we label these fits with $*$, to indicate that cD *are not* disk systems. Their kinematics do not show important rotation and therefore the given D/B values are not to be interpreted as "disk-to-bulge" ratios. Finally, note that some of the galaxies that Postman & Lauer (1995) select as "brightest cluster galaxies" according to their definition (GIN=37, 59, 273, 365, 518, 609, 731), are not the largest and brightest in our cluster sample.

In addition to the pure $R^{1/4}$ law galaxies classified as Es, a large fraction of the early-type galaxies classified as E/S0 deviate little from the de Vaucouleurs profile. They are best fit by low D/B ratio models ($D/B \leq 0.5$ in 60% of the fits, $D/B \leq 1$ in 90% of the fits). It is very difficult to draw a clear division between the two classes of E and S0 without the help of a detailed analysis of the isophote shape analysis or of spatially-resolved spectroscopic information. A final caveat is that the D/B ratios derived here can be subject to substantial systematic errors, as keyed by the quality parameter Q (see the extensive discussion in Paper IV). We will investigate the problem further in a future paper, where the results of the isophote shape analysis of the brightest and largest galaxies of the EFAR sample will be presented.

The spiral galaxies in our sample are fainter and smaller than the other types, confirming the findings of Paper I, where a stronger contamination of the sample by spiral galaxies at the faint end of the luminosity distribution was indicated. Most spirals are clearly disk-dominated, with concentrated bulges ($D/B \geq 1$ in 60% of the cases, $h/R_{eB} \geq 2$ in 60% of the cases). However some of the profiles of these objects are best fit by an $R^{1/4}$ law. Some of them are bulge dominated SB0 but some appear to have spiral arms; the majority of these cases are very small objects ($R_e < 3''$), where the morphological classification is uncertain. Spiral galaxies have a large colour range with a blue tail.

The investigation of the correlations existing between the parameters derived from the fits for the different types of galaxies must take into account the severe selection effects present in the sample and will be discussed in a future paper.

3.5 Selection diameter

Paper I has discussed in detail the selection functions of our sample galaxies based on the photographic diameter D_W which correlates with the D_n diameter (see Figure 5 of Paper I). Figure 17 assesses this result with our final photometric dataset. Panel (a) shows the correlation $\log D_W - \log D_n$ for early-type (filled squares) and spirals and barred galaxies (open squares). A least-squares fit to the early-type sample gives $\log D_n = 0.80 \log D_W + 0.26$ (full line) with 0.09 dex rms scatter in $\log D_n$, corresponding to a (remarkably small) 23% error in D_n. (Note that D_W has not been corrected for galactic absorption, K correction and cosmological dimming. The scatter can be further reduced if zero point corrections from cluster to cluster are applied). The relation is somewhat steeper for the whole sample ($\log D_n = 0.93 \log D_W + 0.06$, dotted line) with a larger rms scatter (0.12 dex in $\log D_n$) due to the presence of some deviant points at low D_n. Panel (b) compares the distribution of the D_W for the EFAR sample of Paper I (full line) to the distribution of D_W for the galaxies with good photometry (calibrations (1) to (4) of §2.2) and classified as early-type (dotted line). The dashed line shows the ratio between the two distributions. For $\log D_W \geq 1.7$ the two samples are nearly identical. At smaller diameters the sample of early-type galaxies with good photometry shrinks the original sample to 60%. Panel (c) shows the correlation between $\log D_n/R_e$ and $\langle SB_e \rangle$. As expected, disk-dominated galaxies deviate strongly from the relation defined by the early-type galaxies. The relation between D_n/R_e and $\langle SB_e \rangle$ allows us to correlate $\log D_W$ directly to the combined quantity entering the Fundamental Plane $FP = \log R_e - 0.3\langle SB_e \rangle$. Panel (d) shows the least-square solution for the early-type sample ($FP = 0.78 \log D_W - 6.14$, full line) and for the whole sample ($FP = 0.92 \log D_W - 6.34$, dotted line). The rms scatter in FP is only marginally larger than that found for log D_n. It can be reduced to the same value by adopting a smaller surface brightness coefficient (0.25 instead of 0.3).

4 CONCLUSIONS

We have presented photometric data for the EFAR sample of galaxies. Our main results are as follows.

1) A total of 2846 CCD images in the R band of 776 galaxies have been collected during 80 nights on 1m class telescopes over 16 observing runs, giving at least two images for 87% of the objects.

2) Absolute photometry in the R band has been collected for 674 galaxies, amounting to 1286 zero point calibrations. These consist of the 404 photoelectric aperture magnitudes already published by Colless et al. (1993) and 685 CCD zero points collected in 18 photometric nights. The remaining 189 zero points come from indirect calibrations. The comparison between photoelectric and CCD aperture magnitudes shows that a typical precision of 0.03 mag per zero point has been achieved. The same conclusion is reached by comparing CCD surface brightness profiles obtained under photometric conditions. 43% of the galaxies have more than one photometric zero point; for 13% of the objects where no calibration was collected, a zero point based on the calibrations of CCD images taken close in time and position on the sky is given. The comparison with existing external calibrations confirms the precision achieved.

3) Total apparent magnitudes, half-luminosity radii and D_n diameters have been determined by means of the seeing-convolved, $R^{1/4}$ plus exponential fitting function described and tested in Paper IV. The algorithm allows for an optimal combination of multiple profiles and a correction for sky subtraction errors. A quality parameter Q is assigned to each fit based on the Monte Carlo simulations performed in Paper IV. This parameter quantifies the estimated maximum systematic errors on the derived photometric quantities. In 90% of the fits $Q \leq 2$, so that the errors on total magnitudes are less than 0.15 mag, and those on R_e less than 25%. The errors on the combined quantity $FP = \log R_e - 0.3\langle SB_e\rangle$ or on the $\log D_n$ diameter are less than 0.03 dex. The quantity FP correlates with $\log D_n$ and is involved in the estimation of galaxy distances through the equation of the Fundamental Plane.

4) The comparison of the derived photometric parameters with those in the literature shows good agreement apart from biases and errors introduced by inadequate data or fitting methods, exactly as expected from the simulations of Paper IV. Parameters can be systematically biased if they are derived from profiles with a small radial extent, which involve large extrapolations, which do not take into account seeing corrections and sky subtraction errors, or use a simple $R^{1/4}$ law when disk components are present. In these cases errors on total magnitudes can easily be larger than 0.5 mag and larger than 50% on R_e.

5) The galaxy type classification shows that 31% of the EFAR objects, originally selected as E's by eye on the basis of photographic images, are in fact spirals or barred galaxies. The morphological type correlates with the parameters derived from the bulge plus disk photometric decomposition. The spiral galaxies in this sample generally have larger D/B ratios and bluer colours than the early-type galaxies.

6) Of the early-type galaxies 17.6% (or 12% of the total sample) are classified E and have a surface brightness profile well described by a simple $R^{1/4}$ law. Early-type galaxies classified E/S0 (70.4% of the early-type sample, 48% of the total sample) have a surface brightness profile fit well by an $R^{1/4}$ bulge plus a moderate exponential disk with $D/B \leq 0.5$ in of 60% the E/S0 cases. Early-type galaxies classified cD which are the brightest and largest objects of their clusters have shallow surface brightness profiles that are best fit with the help of an exponential component which is both significant ($D/B > 0.2$ in 80% of the fits) and extended ($h/R_{eB} > 1$ in 70% of the fits).

7) The photographic diameter D_W used to determine the selection functions of Paper I correlates well with both the D_n diameter and the Fundamental Plane quantity $FP = \log R_e - 0.3\langle SB_e\rangle$, with about 23% scatter for the early-type galaxies in the sample.

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Table 1. Log of CCD observations.

Run #	Date	Nights	Galaxies	Telescope	Setup	Comment
001	87.03.23-26	3	27	MG13	01	NP
002	87.04.28-29	2	17	KP09	02	NP
002	87.05.01-02	2	36	KP09	03	NP
003	87.09.15-29	13	250	MG13	01	NP
004	87.10.24-25	2	36	MG13	01	NP
005	87.11.12	1	33	KP09	03	NP
005	87.11.16-18	3	61	KP09	04	NP
006	88.01.15	1	31	KP09	02	P
007	88.06.10-22	11	332	MG13	01	NP
008	88.06.12	1	23	KP09	03	NP
008	88.06.13-14	2	64	KP09	05	NP
008	88.06.15-17	3	21	KP09	06	NP
009	88.11.10-13	4	54	MG13	01	NP
010	89.10.08-17	7	61	MG13	01	NP
011	90.10.12-18	4	129	JK10	07	P
012	91.05.09-15	6	281	JK10	08	P
013	91.11.29-12.02	4	76	JK10	09	NP
014	92.06.25-07.02	5	178	MG13	01	P
015	92.10.01-07	5	428	CT09	10	NP
016	93.10.06-07	2	79	CT09	11	P
016	93.10.08-12	5	418	CT09	12	P

See Table 2 for a description of the setups used during the runs. See Figure 8 for the periods during which observations have been actually performed. See Table 3 for a detailed log of the photometric observations (indicated by P in the Comments Column; NP indicates non-photometric runs). The telescope codes of Column 5 are as following: MG13=McGraw-Hill 1.3m telescope of Michigan-Dartmouth-MIT (MDM) Observatory; KP09=Kitt Peak 0.9m, JK10=Jakobus Kapteyn Telescope 1.0m, CT09=Cerro Tololo 0.9m.

Table 2. Setups used during the observing runs of Table 1.

Setup	Telescope	CCD	Pixel size (μm)	Field (arcmin)	Scale ($''$/pixel)	Gain (e^-/ADU)	RON (e^-)	Filter	Comment
01	MG13	RCA	30	5.4×3.4	0.636	17.48	64.0	a	
02	KP09	RCA1	30	4.6×7.4	0.862	11.50	70.0	b	f7.5
03	KP09	TEK	27	6.4×6.5	0.776	10.05	8.0	b	f7.5
04	KP09	TEK	27	3.5×3.6	0.433	3.25	8.0	b	f13.5
05	KP09	TEK	27	6.4×6.5	0.776	10.05	8.0	a	f7.5
06	KP09	RCA1	30	4.6×7.4	0.862	11.50	70.0	a	f7.5
07	JK10	GEC3	22	2.9×1.9	0.606	1.00	7.0	c	Binned 2×2
08	JK10	GEC6	22	2.9×1.9	0.606	1.00	8.0	c	Binned 2×2
09	JK10	EEV5	22	6.3×5.8	0.606	0.70	4.5	c	Binned 2×2
10	CT09	TEK2048	24	13.5×13.5	0.792	3.60	4.8	d	Binned 2×2
11	CT09	TEK1024	24	6.75×6.75	0.396	3.60	3.2	d	1 Amplifier
12	CT09	TEK2048	24	13.5×13.5	0.396	3.60	3.2	d	2 Amplifiers

(a) Kron-Cousins filters, Wegner et al. (1991)
(b) KPNO Mould filters
(c) Mould filters, Argyle et al. (1988)
(d) Harris filters.

Table 3. Photometric periods

Run #	Setup	Date	Photometric periods (UT)	# std obsns	# std stars	RMS residual (mag)	# gals
6	02	88.01.15	0214–1037	25	12	0.011	12
11	05	90.10.15	0105–0631	38	9	0.017	24
11	05	90.10.16	1952–0259	65	13	0.027	42
11	05	90.10.17	2049–0523	36	7	0.026	32
12	06	91.05.09	2347–0521	61	12	0.020	14
12	06	91.05.10	2054–0528	57	13	0.010	43
12	06	91.05.11	2037–0351	46	12	0.009	51
12	06	91.05.13	2047–0535	77	17	0.007	57
14	01	92.06.25	0340–1127	30	93	0.015	9
14	01	92.06.27	0320–1131	88	76	0.023	26
14	01	92.06.28	0321–1125	94	76	0.014	21
14	01	92.06.29	0319–1128	122	58	0.015	33
14	01	92.06.30	0325–1004	110	53	0.021	30
14	01	92.07.01	0314–1116	96	43	0.011	12
16	09	93.10.06	0000–0817	19	35	0.013	38
16	09	93.10.07	2356–0854	17	29	0.013	43
16	10	93.10.09	2343–0929	28	57	0.018	117
16	10	93.10.11	0224–0928	25	49	0.019	81

Table 4. Table 4 in landscape mode

Table 5. Photometric Parameters: External Comparisons

Authors	Δm_T		$\Delta \log R_e$		ΔFP		$\Delta\langle SB_e\rangle$		$\Delta\Delta \log D_n$	
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Burstein et al. (1987) [a]	-0.08	0.19	0.10	0.11	-0.029	0.023	0.44	0.42	-0.02	0.03
Jørgensen et al. (1995) [b]	-0.10	0.13	0.03	0.09	0.01	0.022	0.09	0.40	0.005	0.01
Graham (1996)	-0.54	0.30	0.24	0.17	-0.004	0.026	0.80	0.56		
Lucey et al. (1993)[c]	-0.06	0.14	0.009	0.09	-0.02	0.019	0.12	0.37	-0.01	0.01
Guzmán (1993)[c]	0.04	0.16	-0.003	0.13	-0.02	0.022	0.14	0.39	-0.01	0.01

All differences are *Others* − *EFAR*. $\Delta\Delta \log D_n$ denotes the residuals after the subtraction of the surface brightness dependence (see §3.3).
(a) We assume a mean colour of $(B-R) = 1.5$.
(b) We assume a mean colour of $(r-R) = 0.35$.
(c) We assume a mean colour of $(V-R) = 0.5$.

Figure 1. (a) The distribution of mean ellipticities inside R_e. (b) The cumulative fractional distribution of mean ellipticities inside R_e. (c) The integrated magnitude differences $\Delta mag(< R) = mag_c(< R) - mag_e(< \sqrt{ab})$ as a function of the distance $R = \sqrt{ab}$. The magnitude $mag_c(< R)$ is integrated inside an aperture of radius R; the magnitude $mag_e(\sqrt{ab})$ is integrated inside an ellipse of semimajor and semiminor axis a and b, with $R = \sqrt{ab}$. (d) The ellipticity profile of the galaxy GIN=001 as a function of the distance $R = \sqrt{ab}$. The EFAR sample is selected against flattened objects (see discussion in §2.2).

Figure 2. The status of the collected photometric data. (a) The number of galaxies as a function of number of images. (b) The number of galaxies with a given number of photometric zero points. The numbers are split into the contributions of method (1) (CCD calibrations), method (2) (PE calibrations), method (3) (indirect CCD calibrations), and method (4) (indirect PE calibration). (c) The fraction of galaxies with $\leq$ a given number of images. (d) The fraction of galaxies with $\leq$ a given number of photometric zero points. See §2.2 for a discussion of the results.

Figure 3. The temporal variation in R_{CCD} on each of the photometric nights of Table 3. The crosses show the differences $R_{CCD} - R_{PE}$ as in Fig. 3 of Colless et al. (1993) for Runs 11 and 12 (see comment in §2.3). The other symbols code the intercomparisons $R^i_{CCD} - R^j_{CCD}$ between CCD data (magnitudes inside 14-15 arcsec apertures) taken during Runs i and j. Open triangles show comparisons to data from Run 6, filled triangles from Run 11, open squares from Run 12, filled squares from Run 14, open circles from Run 16. Each CCD-CCD comparison appears twice in different panels, with opposite signs. The 6 open circles of night 88.01.15 appear as open triangles on the 93.10.07 (2 points) and the 93.10.09 (4 points) with changed signs. The mean shifts applied to achieve a common zero-point are given in each box (see discussion in §2.3). The resulting mean shift μ and rms σ of each night are given in the lower left, together with the number of points n and the significance $s = \mu/(\sqrt{n}\sigma)$.

Figure 4. The distribution of the differences between CCD and CCD magnitudes (144 comparisons, 14-15 arcsec apertures, dashed line), CCD and photoelectric R magnitudes (361 comparisons, various apertures, dotted line), and of both of them (full line, see §2.3).

Figure 5. The distribution of differences $R_{CCD} - R_{PE}$ with (a) photoelectric magnitude R_{PE}, (b) $(B-R)_{PE}$ colour, (c) the airmass of the CCD observations, and (d) the aperture diameter (in arcsec) used when measuring the magnitudes, for Run 6 (cross), Run 14 (squares) and Run 16 (circles, see §2.3). The analogous plots for Run 11 and Run 12 are given by Colless et al. (1993).

Figure 6. The precision of the CCD photometry. The distribution of differences ΔR_{CCD} between pairs of CCD profiles taken under photometric conditions is shown as a function of the radial distance. The panels on the right side are obtained after applying the sky corrections derived from the fits (see §2.3).

Figure 7. The precision of the indirect calibration. (a) The histogram of the differences $\delta = ZP_{1,2} - ZP_{3,4}$ between the zero point calibrations derived with methods (1) or (2) and the ones derived with methods (3) or (4). (b) The cumulative fraction of $|\delta|$ (see §2.4).

Figure 8. The R-band magnitude arcsec^{-2} of the sky as a function of UT during the 80 nights (given in each box) when CCD images were taken. The symbol P (NP) indicates photometric (non-photometric) nights (see Table 3 for a detailed list of the photometric periods). Filled squares show images calibrated by method (1) (see §2.2), crosses by method (2), filled circles by methods (3) and (4), open circles by second and third-order calibration. Open squares indicate images taken under non-photometric conditions of galaxies where calibrations of type (1), (3) or (4) are also available. The big x-axis tickmark indicates 2 hours spacing in UT. The number in the left corner of each box gives the starting UT. The following nights show anomalous data points. 87.03.25: GIN=773 (NGC 3379 fills the CCD) sky not well determined. 87.04.29: the sky jump is real (GIN=647 observed in other nights with no jumps). 87.05.02: sky jumps real, confirmed by galaxies with multiple calibrations. 87.09.16: sky jumps real, confirmed by galaxies with multiple calibrations. 87.10.25, first jump GIN=106, photoelectric magnitude possibly wrong? The second sky jump is real, GIN=167 has multiple calibrations. 87.11.17: GIN=223 with second order calibration, possible problem with exposure time? 88.06.10: GIN=303, photoelectric magnitude possibly wrong? (see §2.3). 88.06.13: GIN=500 twice, photoelectric magnitude possibly wrong? 88.06.14: the sky jump is confirmed by two galaxies with multiple calibrations (GIN=433 and GIN=557). 88.06.16: the sky jump is real (GIN=532 and 533 observed in other nights with no jumps). 91.05.10: moon at the end of the night. 91.11.29: GIN=088 very weak and radially short profile, calibration uncertain. 91.12.02: moon at the beginning of the night. 92.07.02: the sky jumps are real (GIN=354, 355, and 356 observed in other nights with no jumps). 92.10.06: jump at UT=3:30, GIN=794 (NGC 584 fills the CCD), sky not well determined. Jump at UT=5:30 is real (GIN=149 and 150 observed in other nights with no jumps). 92.10.07: GIN=689, very weak and radially short profile, calibration uncertain. See §2.5 for a discussion.

Figure 9. Comparison between PL and EFAR curves of growth. Filled squares show images calibrated by method (1) (see §2.2), crosses by method (2), filled circles by methods (3) and (4); open squares indicate images taken under non-photometric conditions of galaxies where calibrations of type (1), (3) or (4) are also available. The percentage correction to the sky value needed to eliminate the radial gradient is given, if its absolute value is equal or larger than 1%. See §2.6 for a discussion of the results.

Figure 10. The distributions of the photometric parameters and their photometric precision. Only galaxies with photometric calibrations derived using methods (1) to (4) (see §2.2) are considered. (a) The distribution of $\log D_n$. (b) The distribution of $\log R_e$. (c) The distribution of the photometric fractional precision $\delta D_n/D_n$ (Columns (9) and (10) of Table 4). (d) The distribution of total magnitudes m_T. (e) The distribution of the effective surface brightness $\langle SB_e \rangle$. (f) The distribution of the photometric scatter on SB_e (Column (15) of Table 4). See §3.1 for a discussion of the results.

Figure 11. The fits to the surface brightness profiles. Only profiles with sky values less than 2000 counts per pixel have been plotted. See §3.1 for a detailed description of the plot.

Figure 12. Global quality of the fits. The following cumulative distributions are shown. (a) The quality parameter Q of the fits. (b) The logarithm of disk-to-bulge ratio, with $\log D/B = -3$ for $R^{1/4}$ only fits, and $\log D/B = 3$ for exponential only fits. (c) The type of sky correction applied. (d) The average fractional sky correction. (e) The rms spread of the percentage sky corrections applied to the profiles of each single galaxy. (f) The logarithm of the reduced χ^2 of the fit. (g) The relative improvement of χ^2, measured in units of $\sigma = \sqrt{2/N_{BD}^{free}}$ when a two-component fit is preferred to the $R^{1/4}$ fit. (h) The radial extent of the profiles in unit of R_e. (i) The half-luminosity radius in units of the FWHM of the seeing psf. (l) The logarithm of the total signal-to-noise ratio of the profiles. (m) The extrapolation as percentage of the total flux involved in the derivation of the total magnitudes. (n) The ratio between the effective surface brightness of the galaxy and that of the sky. (o) The percentage galaxy light contamination to the sky value. See §3.2 for a discussion of the results.

Figure 13. Global quality of the fits. (a) The cumulative distribution of the percentage rms values of the corrected sky levels of CCD images having multiple objects for fit quality $Q = 1$ (full line), $Q \leq 2$ (dotted line) and $Q \leq 3$ fits (dashed line). (b) The correlation between the estimated maximum galaxy contamination of the sky value and the applied mean sky correction (if different from zero). Open circles show $Q = 1$ fits, dots $Q = 2$ fits, and crosses $Q = 3$ fits. The line shows the expected upper limit. (c) The cumulative distribution of the rms of the seeing values Γ normalised to their mean values, for CCD images which contain more than one program galaxy for fit quality $Q = 1$ (full line), $Q \leq 2$ (dotted line) and $Q \leq 3$ fits (dashed line). (d) Cumulative distribution of quality of the (absolute) differences in magnitude between the relative normalisations of the multiple profiles available for a single galaxy as computed by the optimal combination algorithm and as resulting from the fitting procedure (see Equations 2 and 10 of Paper IV), for fit quality $Q = 1$ (full line), $Q \leq 2$ (dotted line) and $Q \leq 3$ fits (dashed line). See §3.2 for a discussion of the results.

Figure 14. The comparison of the photometric parameters with external sources. The differences in total magnitudes $\Delta m_T = m_T(Other) - m_T(EFAR) + \Delta ZP$, in the logarithm of the half-luminosity radius $\Delta \log R_e = \log R_e(Other) - \log R_e(EFAR)$, in the correlated quantity $\Delta FP = \Delta \log R_e - 0.3\Delta\langle SB_e \rangle$, and in the average surface brightness $\Delta\langle SB_e \rangle = \langle SB_e \rangle(Other) - \langle SB_e \rangle(EFAR) + \Delta ZP$ are shown as a function of the disk-to-bulge ratio D/B and scale length ratio h/R_{eB} of the fits. Panel (a) shows the comparison with Burstein et al. (1987), panel (b) with Jørgensen et al. (1995), panel (c) with Graham (1996), panel (d) with Lucey et al. (1991), panel (e) with Guzmán (1993). Filled dots show $Q = 1$ fits, open dots $Q = 2$ and crosses $Q = 3$ fits. The crosses at the bottom right corners show (if given) the errorbars quoted by the different authors. See §3.3 for a discussion of the results.

Figure 15. The comparison of the D_n diameters with external sources. The differences $\Delta \log D_n = \log D(Other) - \log D_n(EFAR)$ are shown as a function of $\langle SB_e \rangle(EFAR)$. Plot (a) shows the comparison with Burstein et al. (1987), plot (b) with Jørgensen et al. (1995), plot (c) with with Lucey et al. (1991), panel (d) with Guzmán (1993). Filled dots show $Q = 1$ fits, open dots $Q = 2$ and crosses $Q = 3$ fits. The crosses at the bottom right corners show (if given) the errorbars quoted by the different authors. The lines show the expected $\Delta \log D_n$ for the differences in the surface brightness defining D_n and for an $R^{1/4}$ law. See §3.3 for a discussion of the results.

Figure 16. The differential (upper boxes) and cumulative (lower boxes) distributions of galaxies according to their total absolute magnitude, $\log R_e$ in kpc, D/B ratio, h/R_{eB} ratio, $(B - R)$ colour and morphological type. Panel (a) is for cDs, (b) for Es (early-type galaxies with a simple $R^{1/4}$ fit), (c) for E/S0s (early-type galaxies with a $D/B > 0$ fit), (d) for spirals and barred galaxies. See §3.4 for a discussion of the results.

Figure 17. The relation between the photometric parameters and the photographic diameter D_W used in the selection functions (see Paper I). Only galaxies with photometric calibrations obtained using methods (1) to (4) (see §2.2) are plotted. Filled squares show early-type galaxies, open squares spirals and barred galaxies. (a) The correlation between $\log D_W$ and $\log D_n$. Both diameters are measured in arcsec. The full line shows the best fit to the early-type sample, the dotted line to all of the galaxies. (b) The distribution of $\log D_W$ (in scaled units) for the whole sample of Paper I (full line) and for the sample of early-type galaxies with photometric calibrations obtained using methods (1) to (4) (see §2.2, dotted line). The dashed line shows the ratio of the two. (c) The relation between $\log D_n/R_e$ and $\langle SB_e \rangle$. The dotted line shows the position of Freeman's disks. (d) The relation between $\log D_W$ and the quantity $FP = \log R_e - 0.3\langle SB_e \rangle$. The full line shows the best fit to the early-type sample, the dotted line to all of the galaxies. See §3.5 for a discussion of the results.