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An image database. II. Catalogue between $\delta = -30°$ and $\delta = 70°$*

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Abstract. — A preliminary list of 68.040 galaxies was built from extraction of 35.841 digitized images of the Palomar Sky Survey (Paper I). For each galaxy, the basic parameters are obtained: coordinates, diameter, axis ratio, total magnitude, position angle. On this preliminary list, we apply severe selection rules to get a catalog of 28.000 galaxies, well identified and well documented. For each parameter, a comparison is made with standard measurements. The accuracy of the raw photometric parameters is quite good despite of the simplicity of the method. Without any local correction, the standard error on the total magnitude is about 0.5 magnitude up to a total magnitude of $B_T = 17$. Significant secondary effects are detected concerning the magnitudes: distance to plate center effect and air-mass effect.

Key words: galaxies: general — catalogue — galaxies: photometry

1. Introduction

We are aiming at collecting the basic information for principal galaxies in order to get the deepest magnitude- or diameter-limited samples. In a companion paper (Paturel et al. 1995; hereafter Paper I), we explain how we used 35.841 images, digitized from the Palomar Sky Survey (PSS), to built a large catalog of 68.040 galaxies. For each galaxies the main photometric parameters are calculated (i.e., coordinates, apparent magnitude, apparent diameter and axis ratio, position angle). From the raw list of 68.040 galaxies we now extract a first catalog with best defined objects. For this purpose we impose severe rules of selection. A 2σ rejection rule is used except for parameters less sensitive for which only a 3σ rejection is used.

Let us enumerate and justify these rules:

1. The declination will be limited to the range $\delta = -30$ deg to $\delta = 70$ deg. Below $\delta = -30$ deg, only red PSS charts are available while we want to calibrate with blue magnitudes. Above $\delta = 70$ deg coordinates and position angles must be treated with more sophisticated astrometric program.
2. The position angle β_{image} of the PSS chart must be within the range $(-9, +9)$ deg. This range corresponds to a 3σ level. It is to be noted that the position angle of images near the pole can differ from zero when the digitized region is far from the center of the chart. It is another reason to use a 3σ rejection instead of a more severe 2σ one, because even at $\delta = 70$ deg a deviation from zero can be expected.
3. A galaxy must have only one counterpart on the image and vice versa. Thus, overlapping objects are rejected.
4. The standard deviation on the coordinates of reference stars must be smaller than 9 arcsec. This corresponds to a 2σ rejection.
5. The number of reference stars must be larger than 14. According to Fig. 4 of Paper I, this limit corresponds to a mean Standard Deviation $\sigma_{\alpha\delta}$ of about 5 arcsec, i.e. about half the accepted 2σ limit.
6. If one of the parameters B_i, $\log D_i$, $\log R_i$ differs from its counterpart in LEDA by more than 3σ (σ being calculated from the Lagrangian polynomial seen in Paper I), the galaxy will be rejected. This test is not applied on the position angle because it is known that several of them are badly measured in some catalogs and thus in LEDA (see the discussion in Karachentsev et al. 1993).
7. If all the parameters have a deviation by less than 1σ from its LEDA counterpart the galaxy will be kept even if the coordinates differ significantly from those given in LEDA (in the limits accepted for the first selection). This condition is applied only for galaxies having a position angle in agreement with the one given in LEDA and an axis ratio larger than 0.5 in log (i.e. $\log R_i > 0.5$). This rule allows us to correct bad coordinates for well recognizable galaxies.

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*The catalog will be published as a Monography of the Extragalactic Database and distributed via the CDS archives

8. The last rule of selection is the rule on d_1 and d_2. We have seen (Paper I) that d_1 measure the agreement between an object and a given galaxy while d_2 measure the same agreement for the second possible object. If d_1 is very small we can accept smaller d_2 otherwise d_2 must be larger (in other words, if the agreement is not perfect the cross-identification is accepted only if there is no other possible object). After several trials we apply the following conditions: if $d_1 \leq 0.3$ then $d_2 - d_1$ can be as small as 0.1 if $d_1 = 0.9$ then $d_2 - d_1$ must be larger than 1.8 with the additional condition that for non accurate coordinates in LEDA the quantity $d_2 - d_1$ must be twice as large. Using a linear approximation between these conditions we obtain that the authorized difference $d_2 - d_1$ is given by:

   $(d_2 - d_1) = 3.d_1 - 0.7$ for accurate coordinates
   $(d_2 - d_1) = 6.d_1 - 1.4$ for non accurate coordinates

   We have not to consider cases where these relations give $d_2 - d_1 < 0$ because by its own definition we have always d_2 larger than d_1 (it can be equal but this case is not considered anymore because of rejection of multiple cross-identifications). The largest accepted value of d_1 is $d_1 \leq 0.9$ for accurate coordinates in LEDA, but this value is multiplied by the square root of the weights of accurate coordinates to not accurate ones (i.e. $\sqrt{9}/6$). Thus, $d_1 \leq 1.1$ for not accurate coordinates.

2. Reduction to standard systems

Using the selection rules seen in the previous section, we filter our first list of 68040 galaxies. Galaxies not responding to the rules are rejected. When a galaxy is measured several times a weighted mean value of each parameter is calculated, the weight being the inverse of the square of the distance d_1 in order to reproduce the classical $1/\sigma^2$ weighting. We had to pay attention to the calculation of this mean for periodic parameters, like the position angle or the right ascension. For instance, a position angle of 179 deg is nearly identical to a position angle of 1 deg. An ordinary mean would have given an erroneous value of 90 deg, the correct answer being 0 deg (or equivalently 180 deg). For this kind of means we wrote a special subroutine. As seen in Paper I, the standard system for magnitudes and diameters is the system used in the Third Reference catalog (RC3, de Vaucouleurs et al. 1991). There is no well defined reference for position angle. We use position angles collected in LEDA, essentially from UGC (Nilson 1973), ESO-B survey (Lauberts 1982), ESGC (Corwin, private communication) and FGC (Karanchensev et al. 1993). For coordinates, we refer to the accurate coordinates collected in LEDA. These coordinates come essentially from references listed in Paturel et al. (1989a). Additional references were used. Unfortunately the origin of coordinates is not given in LEDA and it is difficult to trace all references having provided it with accurate cordinates.

These comparisons between parameters extracted from images and standard parameters is made with first order equations. Second order effects will be studied in the next section. In order to have a valuable comparison, we limit the comparison to galaxies having good measurements in LEDA. This means more precisely:

- $B_T \leq 17$ mag.
- $\sigma(B_T) \leq 0.1$
- $\log D_{25} \geq 0.9$

The test sample constructed in this way contains 1435 galaxies. For the comparison of position angle we add the condition $\log R_{25} \geq 0.5$, and for the comparison of coordinates we impose that they are accurate in LEDA (i.e. better than 10 arcsec in R.A. or DEC.). The best solutions are the following:

$$\beta_{\rm L} = \beta_i$$
$$\sigma(\beta_{\rm L}) = 4.4\,{\rm deg}$$

$$(B_T - 13.47) = (1.15 \pm 0.01)(B_i - 13.60)$$
$$\sigma(B_T) = 0.46 \text{ mag.}$$

$$(\log D_{25} - 1.27) = (1.11 \pm 0.01)(\log D_i - 1.27)$$
$$\sigma(\log D_{25}) = 0.095$$

$$(\log R_{25} - 0.21) = (1.15 \pm 0.02)(\log R_i - 0.25)$$
$$\sigma(\log R_{25}) = 0.11$$

Figures 1 and 2 illustrate these comparisons.

3. Search for secondary effects

Several effects have been searched for, on apparent magnitudes, apparent diameters and axis ratios. Three tests showed significant effect:

- *Distance to the center* effect for apparent magnitudes.
- Declination (or air-mass) effect on apparent magnitudes.
- Brightness effect on apparent magnitudes

Let us give more details about each of them.

It is well known that Schmidt plates exhibit a strong photometric effect depending on the distance to the center of the plate. Despite the relatively poor quality of apparent magnitudes B_i we made the test and found a tiny but significant effect. We adopted the relation:

$$(B_T - B_i) = (-0.0006 \pm 0.0002)\Delta r - (0.043 \pm 0.032)$$

where Δr is the distance (in mm) between the considered galaxy and the center of the PSS chart it is extracted from. This relation is illustrated in Fig. 3.

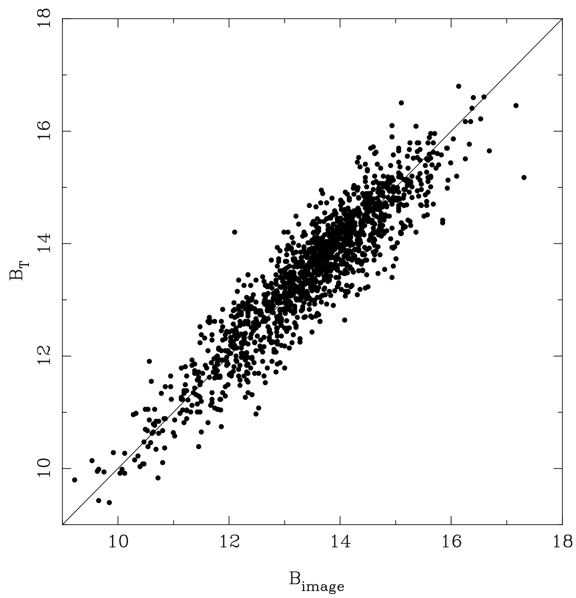

Fig. 1. Comparison between reduced apparent magnitudes and standard B_T magnitudes

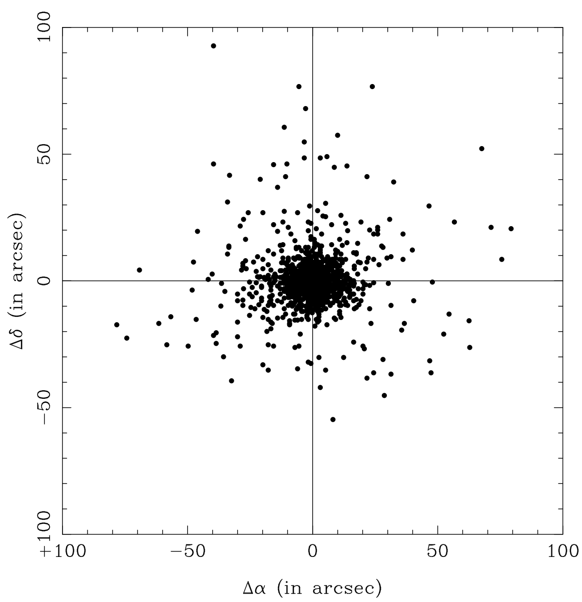

Fig. 2. Comparison between calculated coordinates and standard ones

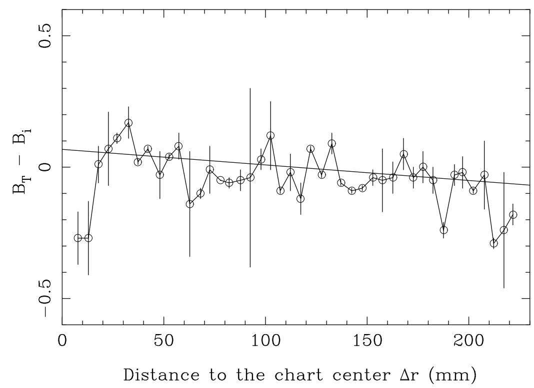

Fig. 3. Effect on magnitudes of the distance to the center of the chart. This effect is significant although very small. The straight line gives the least-squares solution

$$(B_T - B_i) = (-0.167 \pm 0.055) \sec Z + (0.160 \pm 0.065)$$

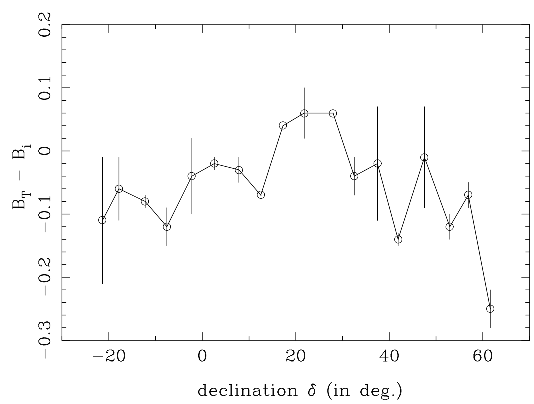

Fig. 4. Effect on magnitudes of the declination of the galaxy. The maximum nearly corresponds to the latitude of the Mount Palomar Observatory. This effect is probably related on the air-mass

The latitude of Mount Palomar Observatory is about 33 deg. Plates near $\delta = -30$ deg are necessarily taken with high air-mass and this can introduce a declination effect or more precisely an air-mass effect. A plot $(B_T - B_i)$ versus δ shows a maximum near $\delta \approx 33$ deg (Fig. 4). A plot $(B_T - B_i)$ vs. sec Z confirms this effect (Fig. 5). For the calculation of the zenithal distance Z we assumed that the plate was obtained just at the meridian (sideral time equal to the right ascension). A least-squares solution leads to the adopted significant correction:

The mean surface brightness m' (in mag.arcsec^{-2}) is defined as $B + 5\ \log D_{25} - 5.26$ (Vaucouleurs et al. 1991), where B is the B-magnitude. In a recent paper (Paturel et al. 1994) we have shown that the classical effect of "mean surface brightness" (Holmberg 1958; Vaucouleurs & Vaucouleurs 1964) is an artefact which is directly related on the accuracy of the magnitude system. For a standard deviation of about 0.5 mag. we predict a slope $\partial B/\partial m' = -0.5$. The least-squares solution gives:

$$(B_T - B_i) = (-0.48 \pm 0.02) m' - \text{cst}.$$

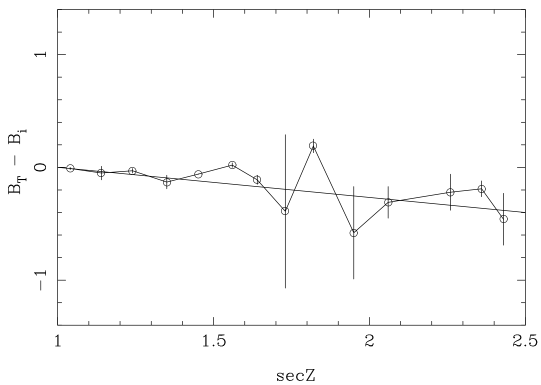

Fig. 5. Effect on magnitudes of the air-mass. This effect is significant. The straight line gives the least-squares solution

in good agreement with the prediction. This confirms our conclusion that this effect should not be taken into account, except if one wants to improve the accuracy of the magnitude by assuming that the mean surface surface brightness is constant for all galaxies (for more detailed discussion see Paturel et al. 1994). Under this assumption, the accuracy of our magnitudes B_i can be improved by a factor $1/\sqrt{2}$ (i.e. the standard deviation can be reduced to about 0.35). In other words, it is possible to have another estimate of the B_T magnitude from the apparent diameter and to average it with the direct estimate B_i in order to reduce the standard deviation by $1/\sqrt{2}$).

4. The catalog

Applying the selection rules, the reduction equations and the first two secondary effects (the mean surface brightness effect will not be taken into account) we obtain a catalog of 22.497 galaxies with coordinates, magnitude, diameter, axis ratio and mean surface brightness for each galaxy and position angle for all non face-on galaxies. It provide us with 4.634 new magnitude (when we are saying *new* it means that the corresponding galaxies had not yet a magnitude estimate), 7.383 new diameters, 8.139 new axis ratios, 2.939 new position angles[1] and 4.483 new accurate coordinates. Note that position angles are given only where $\log D_{25} \geq 0.3$. The catalog will be published as a Monography of the Extragalactic Database and distributed via the CDS archives. Table 1 presents the first page of this catalog. The columns are aranged as follows:

- *Column 1*: PGC/LEDA name. LEDA is the extension of PGC name (Paturel et al. 1989a, b) used in the LEDA database.
- *Column 2*: Name according to a hierarchy (see Paturel et al. 1989a).
- *Column 3*: R.A. and DEC (1950) in hours, min, seconds, tenths and in degrees, arcmin and arcsec, respectively. Accurate coordinates (better than $10''$ are given with an asterisk (*).
- *Column 4*: Position angle (in degrees) counted from North to the East and its mean error.
- *Column 5*: Total apparent blue magnitude B_T and its mean error.
- *Column 6*: Decimal logarithm of the apparent diameter D_{25} (in 0.1 arcmin) approximately at the 25 B.mag.arsec^{-2} brightness level and its mean error.
- *Column 7*: Decimal logarithm of the axis ratio R_{25} (major axis divided by minor axis) and its mean error.

Table 2 gives a list of correction found during the digitization phase. This list is presented with the same conventions as the previous published list (Paturel et al. 1991). (**code 1**: error in coordinates; **code 2**: error for a name; **code 3**: name missing; **code 4**: error on data; **code 5**: not a galaxy)

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[1]Position angles are given only where $\log R_25 \geq 0.3$.