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Photometric investigations of NGC 2577 and NGC 4310 Lenticular Galaxies

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Abstract

In this study, two lenticular galaxies (NGC 2577, NGC 4310) have been chosen to study their morphological and photometric properties, by using The IRAF ISOPHOTE ELLIPSE task with griz-Filters. Observations are obtained from the Sloan Digital Sky Survey (SDSS) which are reach now to the Data Release (DR14). The data reduction of all images (bias and flat field) have been done by SDSS pipeline. The surface photometric investigations were performed like the total magnitude, together with isophotal contour maps, Surface brightness profiles and a bulge/disk decomposition of the images of the galaxies, although the disk position angle, ellipticity and inclination of the galaxies have been done.

Keywords: Lenticular Galaxy, galaxy, Surface Photometry, and individuals: NGC 2577, NGC 4310.

إستقصاءات فوتومترية للمجرتين العدسية NGC 2577 و NGC 4310

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الخلاصة

الملخص من هذه الدراسة، أنه تم اختيار مجرتين عدسيتين (NGC 2577 و NGC 4310) لدراسة خصائصهما المورفولوجية والفوتومترية ، باستخدام IRAF ISOPHOTE ELLIPSE للمرشحات (***griz***). وقد تم الحصول على البيانات والصور من موقع Sloan Digital Sky Survey (SDSS) والذي وصل الآن إلى الإصدار (DR14). وقد تم معالجة البيانات ولجميع الصور منها (bias and flat field) بواسطة المعلومات المتاحة على موقع SDSS. وقد تم إجراء الاختبارات الضوئية السطحية للمجرتين، مثل الحجم الكلي، جنبا إلى جنب مع الخرائط الكنتورية، والمظهر الجانبي للسطوع السطحي وكذلك مساهمة (النتوء المركزي / القرص) لصور المجرات، وكذلك فقد تم دراسة زاوية موقع القرص، الاهليلجية وميل المجرات موضوع الدراسة.

1 Introduction

Surface photometry of galaxies - the quantification of the 2D light distribution - is a powerful tool in the study of morphology of galaxies. Although surface photometry requires better signal-to-noise definition than aperture or integrated photometry, it allows us to see, and measure, morphological detail that is otherwise hidden[1]. According to Hubble, galaxies can be divided into the following types: elliptical (E), lenticular (S0), spiral or barred spiral (S, SB), and irregular (I). His original two-dimensional classification was known as the "tuning-fork"[2]. In this study, two lenticular galaxies have been chosen, which is as fallows:

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NGC 2577: in the cancer constellation, the SA0 morphological type of this galaxy was classified by a visual inspection of color images using the Sloan Digital Sky Survey Data Release 7 (DR7); where the SA0 types show no bar feature[3]. The morphological appearances of NGC 2577 lenticular galaxy are symmetrical and it is small but fairly bright, with a bright, condensed core. The outer envelope is bright and fairly well defined and the envelope has a grainy texture [4]. See Figure-1.

NGC 4310: The barred lenticular galaxy in Coma Berenices Constellation which is classified as (R') SAB0^+(r)?[5], this highly inclined spiral galaxy has a large, bright, elongated core in a fainter disc. Photographs show evidence of a dust lane bordering the core along the western flank. In visible bands, the galaxy is moderately faint but is well seen at medium magnification as a well a defined oval of even surface brightness, elongated SSE-NNW [4]. See Fig. 2 and Table-1 which represents the essential notes for NGC 2577 and NGC 4310.

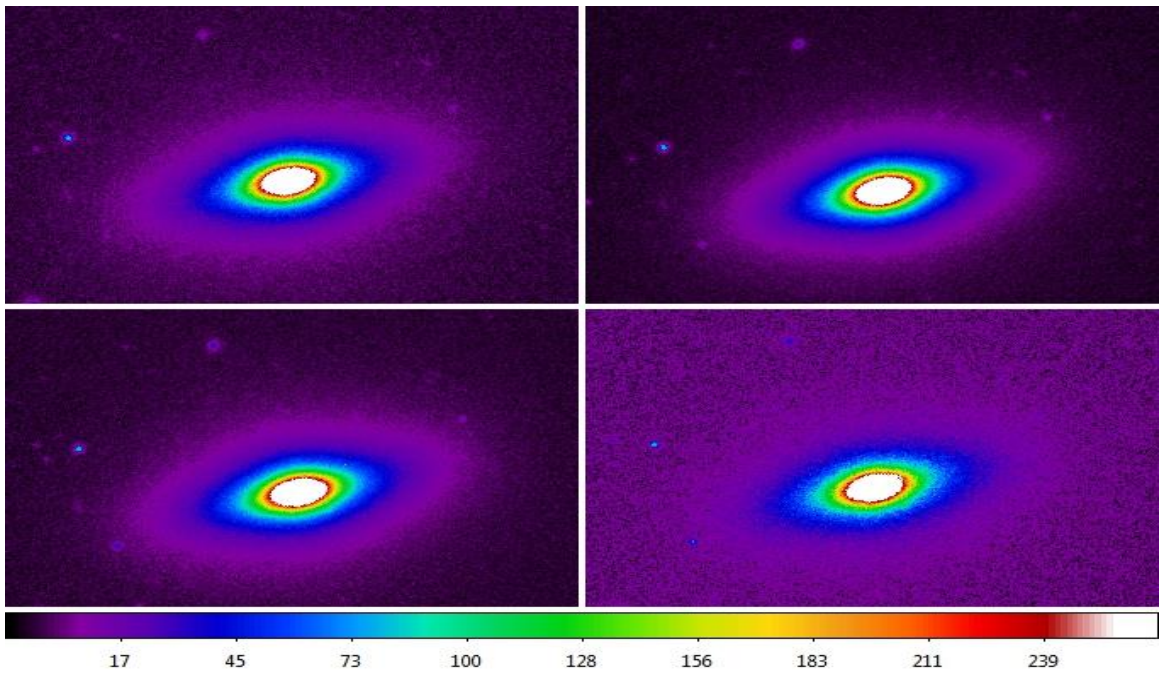


Figure 1 False-Color images of NGC 2577 lenticular galaxy with **griz**-Filters, from left to right. North is up and East is at left.

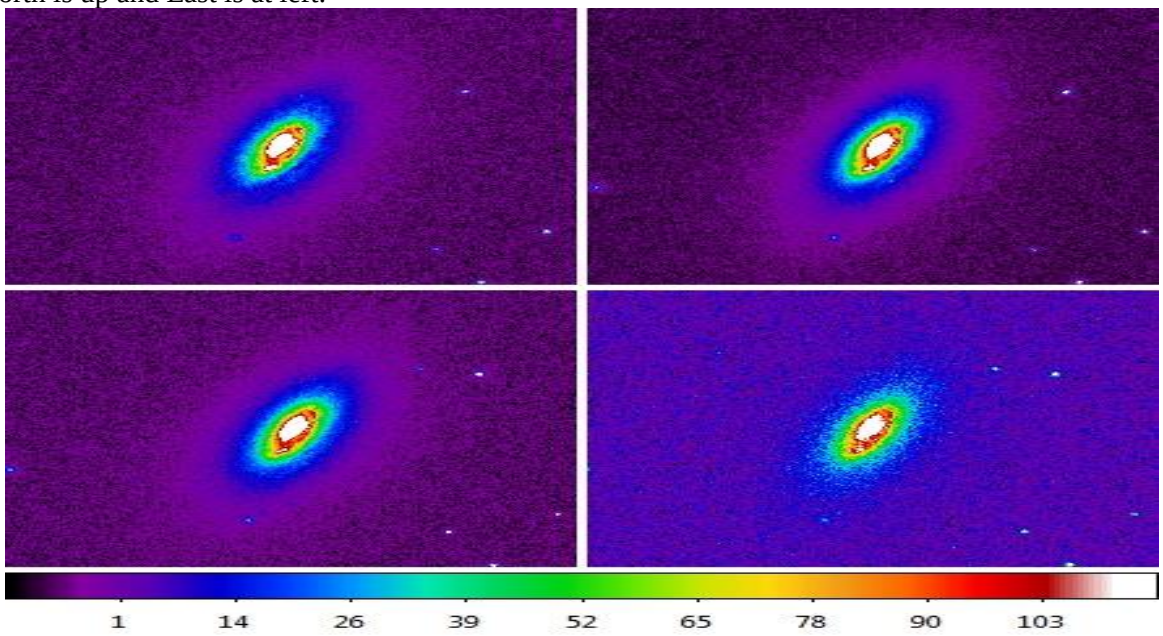


Figure 2-False-Color images of NGC 4310 lenticular galaxy with **griz**-Filters, from left to right. North is up and East is at left.

Table 1-Essential Notes For NGC 2577 & NGC 4310.

Characteristics	NGC 2577	NGC 4310
Classification	*SA0*	*(R')SAB0^+(r)?*
Total apparent magnitude in B-band	*13.28*	*13.08*
Total absolute magnitude in B-band	*-19.30 ± 0.52*[a]	*-17.70 ± 1.04*[a]
d_{25}, arcmin minor axis	*1.1*	*1.2*
d_{25}, arcmin major axis	*1.8*	*2.2*
i, deg	*76.3*[a]	*90*[a]
P.A., deg[J2000]	*105*[a]	*147.9*[a]
RA(2000)	*08h22m43.4s*	*12h22m26.3s*
DEC(2000)	*+22d33m11s*	*+29d12m33s*

[a] HyperLEDA(Makarov et al. 2014)[6].

2 OBSERVATIONAL DATA AND REDUCTION PROCEDURE

Data is obtained from the seventh Sloan Digital Sky Survey (SDSS) Data Release (DR7), which is reach now to (DR14)[7]. The bias and flat field were corrected for all images by SDSS pipeline.

The subsequent data reduction was carried out using the IRAF image-reduction Package as follows[8]:

1. The sky background signals is subtracted by choosing empty regions in the image frame far from objects and measures its average intensity value.
2. Masking is done for the superimposed and nearby objects, stares or galaxies as shown in Fig. 3.
3. The IRAF ISOPHOTE ELLIPSE task is applied to obtain the intensity and structural profiles.
4. For each intensity profile, the followings are done before fitting:

- Conversion from pixel units to arcsec^2: by dividing on the scale (1 pixel = 0.396" for Apache Point 2.5m Observatory (APO)).
- Normalized for exposure: by dividing frames by the exposure time value given in the header (the value is the same for all filters, it equals 53.907456 seconds).
- Transformed to the standard system (using the zeropoint, atmospheric extinction and airmass of the SDSS photometric system at the time of observation, see Table 2) by multiplying the counts by the factor f where:

$$\boldsymbol{f} = 10^{(z_p + k*airmass)} \quad (1)$$

Where $\boldsymbol{z_p}$ and k are the zeropoint magnitude and the atmospheric extinction, respectively.

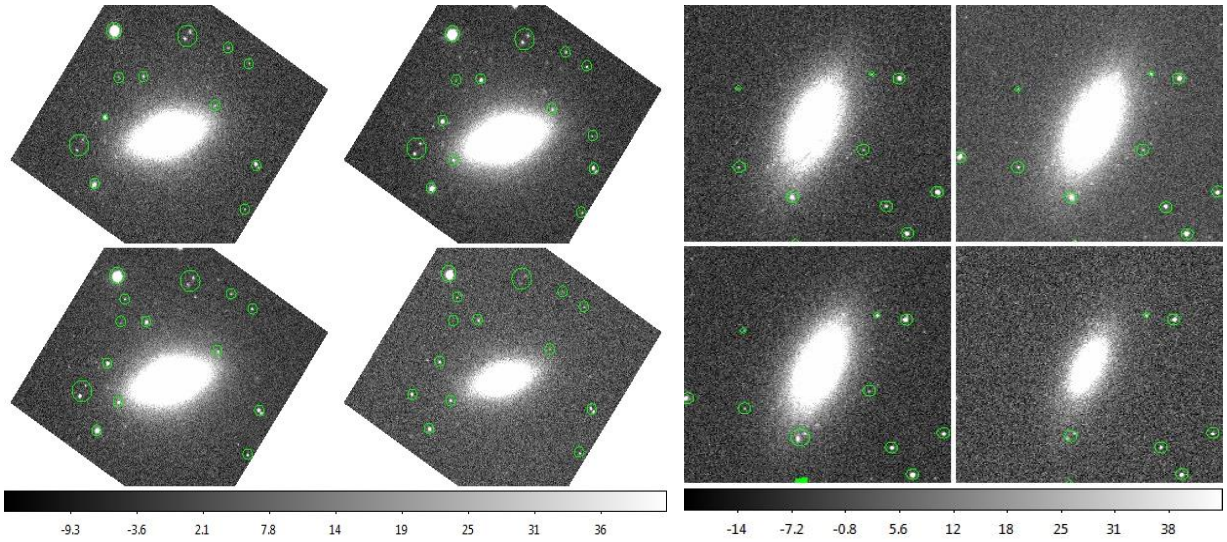


Figure 3-*griz*-Filters overlay with mask regions, North is up and East is at left. Left NGC 2577 and Right NGC 4310.

Table 2-Airmass, zeropoint, and atmospheric extinctions of the SDSS photometric system at the time of observation

Galaxy	Band	Airmass	Zeropoint	Atmospheric Extinction
NGC 2577	***g***	1.193	-24.34	0.186
	r	1.18	-23.94	0.104
	i	1.18	-23.55	0.062
	z	1.9	-21.88	0.053
NGC 4310	***g***	1.194	-24.35	0.186
	r	1.181	-23.95	0.1015
	i	1.184	-23.55	0.061
	z	1.19	-21.88	0.054

- Conversion to magnitude units by the well known formula[9]:

$$\boldsymbol{m} = -2.5\log(I) \quad (2)$$

- All the data were corrected for Galactic extinction based on NASA/IPAC EXTRAGALACTIC DATABASE (NED).

Given the adopted distance to NGC 2577 galaxy from used the direct Tully-Fisher relation in three (JHK) bands [10], which is about 37.7 Mpc, and 9.7 Mpc from Tully est method for NGC 4310[11], the image scales are 182.78 pc/arcsec and 47.03 Mpc respectively.

3 Results and Discussion

3.1 Morphological Description and Contour maps

The ***gzri***-images of NGC 2577 lenticular galaxy were shown in Figure-1. The galaxy has a disky system with a bright bulge to about 14.86", with no evidence to any bar beyond the bulge. The galaxy has a symmetric shape, the brightness decrease at the disk regions until it dissolves with the sky at the end of disk to about 42.95".

Figure-2 shows the ***griz***-images of the NGC 4310 bared lenticular galaxy. The galaxy has a nucleus component to about 8.4", with a fragmented bar component extended to about 14.4". The disk component extended to about 49.65" beyond the bar.

The ***griz***-isophotal contour maps of NGC 2577 and NGC 4310 lenticular galaxies are shown in Figure- (4 & 5). The surface brightness levels are listed in Table-3.

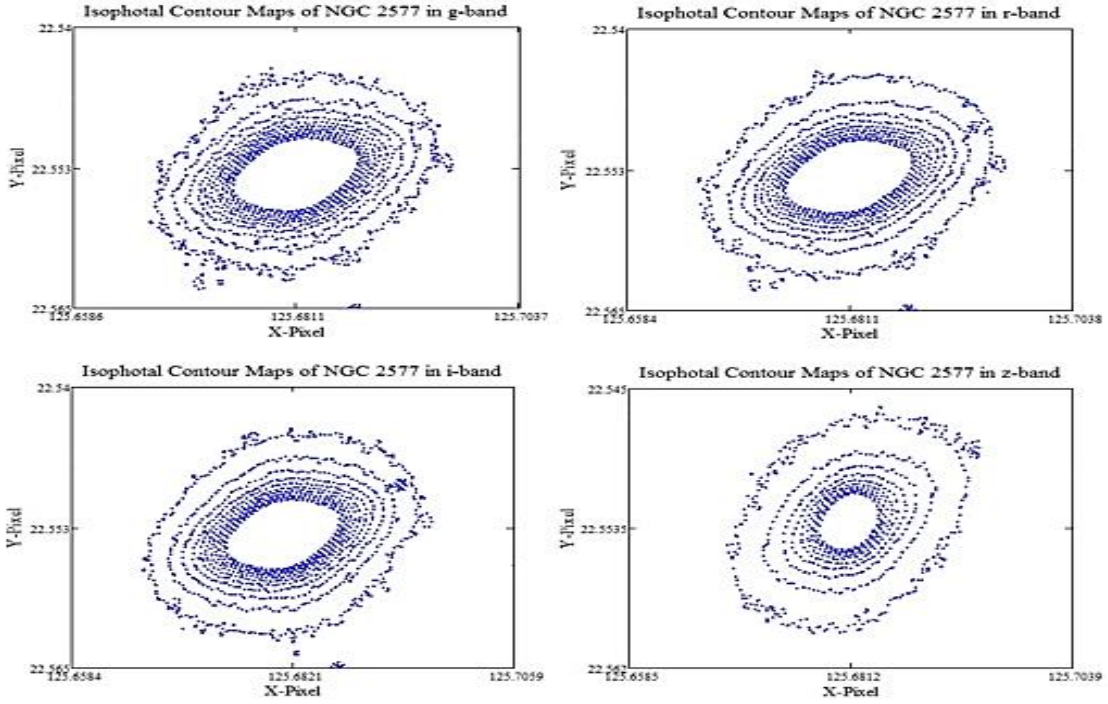


Figure 4-Contour Maps of NGC 2577 Lenticular Galaxy in gri and **z**-bands, North is up and East is at left.

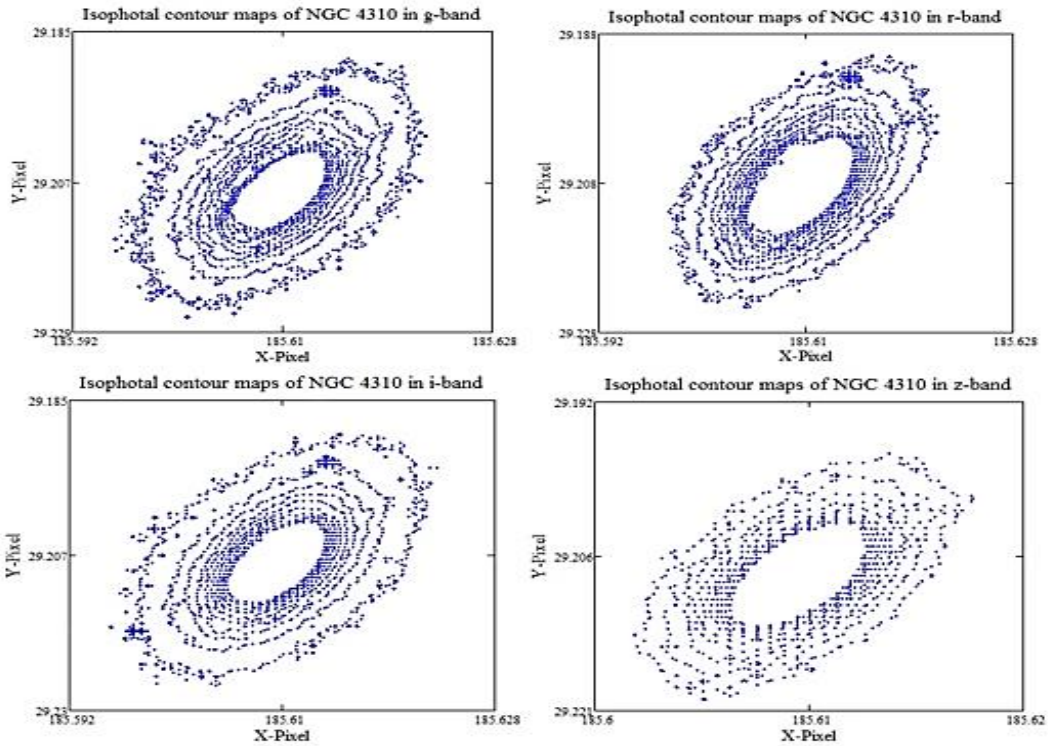


Figure 5-Contour Maps of NGC 4310 Bared Lenticular Galaxy in **gri** and **z**-bands, North is up and East is at left.

Table 3-Isophotal Contour levels of NGC 2577 and 4310 Lenticular Galaxies.

Galaxy	Band	Outer isophot level (mag)	Outer isophot level (mag/arcsec^2)	Steps
NGC 2577	***g***	21.76	19.74	0.625
	r	23.45	21.44	0.867
	i	20.64	18.63	0.697
	z	25.76	19.42	0.92
NGC 4310	***g***	22.37	21.3	0.867
	r	23.3	21.3	0.59
	i	20.98	18.97	0.753
	z	27.52	21.18	0.357

3.2 Geometrical Properties: Position Angle, Ellipticity and B4 Profiles

The position angle (P.A.), ellipticity (ε ≡1−b/a) and B4 (4th harmonic deviations from ellipse) of the two galaxies isophotes were obtained as a function of ***r***, the distance from the center of the galaxy using the ellipse task of the Space Telescope Science Data Analysis System (STSDAS) library in IRAF image-reduction system. The dependences of the position angle, ellipticity and B4 profiles on the distance from the center of the galaxy ***r*** were presented in Figures- (6, 7, 8) respectively. It is noticed that the profiles show a similar behavior in the different bands.

For ***NGC 2577*** , the PA is increased from the center on galaxy to about 17.9" reaches to about 159°, then became constant at approximately 130° with some fluctuation in the end of disk at about 60". The ellipticity profiles of NGC 2577 increase from 0.07 in the center to about 0.5 at 18.8", the decreases to 0.027 In the end of disk region (r = 74.96"). then from using Lu equation[12] the inclination of the disk was calculated; which is found to be 47.06°±12.6.

The B4 (4th harmonic deviations from ellipse) profile illustrated in Figure-8(a) and presented in Table-4 shows that the general trend of the galaxy is disky.

For ***NGC 4310*** from the inside of the bulge to about 6.8" the PA is fluctuate, then decreases to about 108.1º, after this it increases gradually, So up to 114.25° at about 14.5", then became almost constant to the end of the disk. The ellipticity profiles of NGC 4310 decreases from 0.5 at 0.5" to

about 0.43 at 2.46", then became increases rapidly to 0.65 at 8.12", and at the outer region of the galaxy after 8.12" the ellipticity has almost a fixed value at about 0.514. The mean value of ellipticity profile is (0.55±0.043). Ellipticity values were using in using Lu equation[12] to calculate the inclination of the disk which is found to be 65.57°±3.05.

The mean value of the B4 profiles is 0.0083, and illustrated in Figure-8(b) and presented in Table-4 shows that the general trend of the galaxy is a disky system.

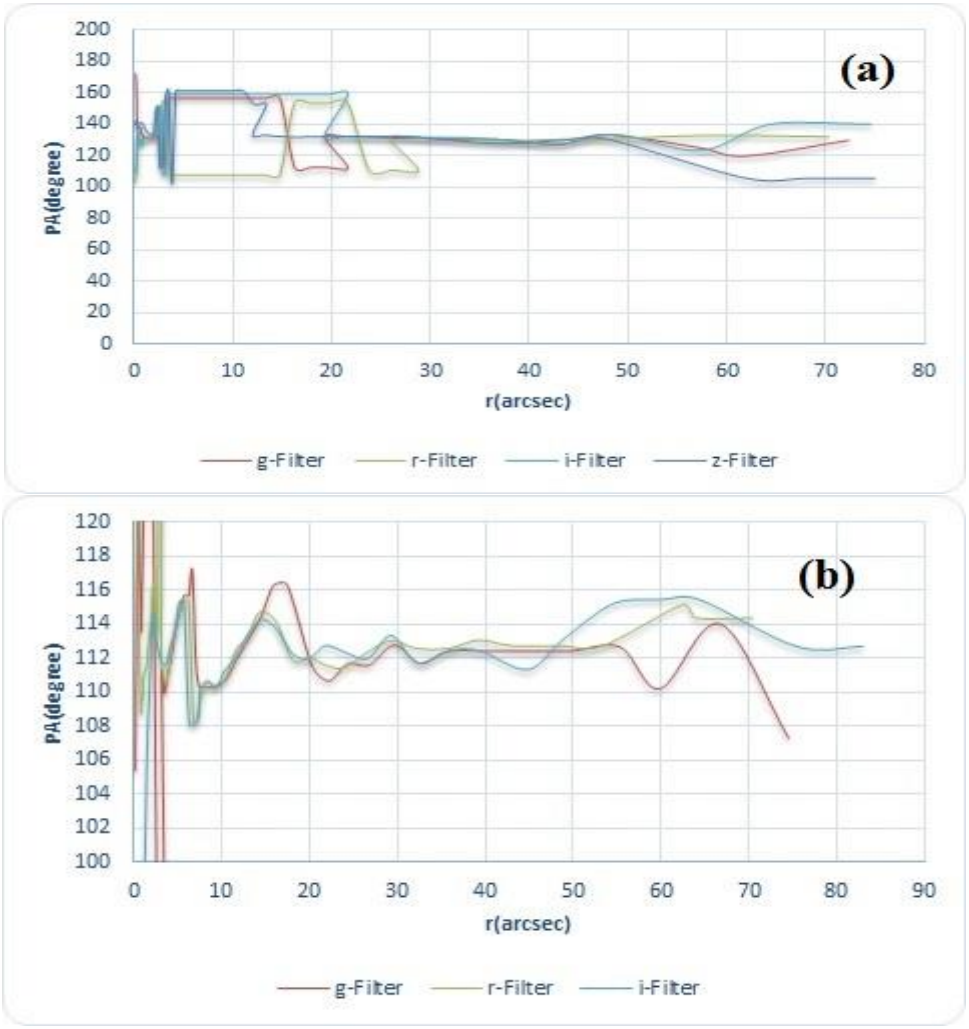
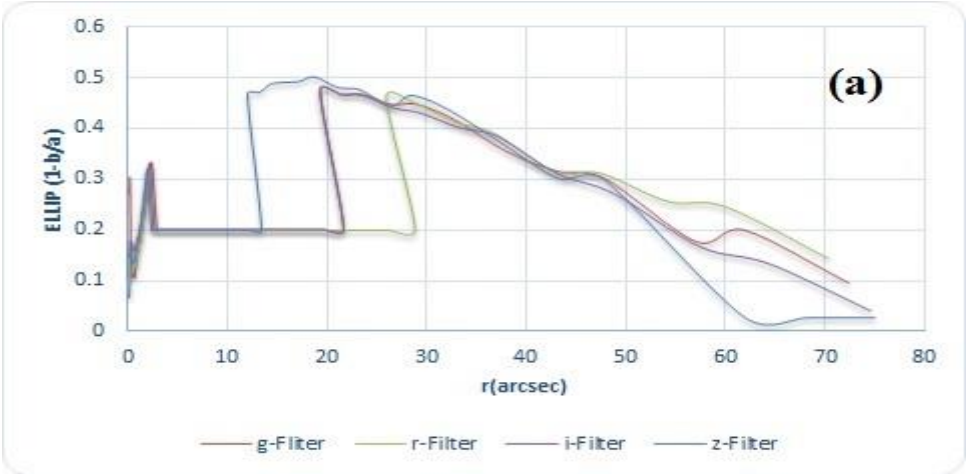


Figure 6-Position angle profiles of a- NGC 2577 and b- NGC 4310..



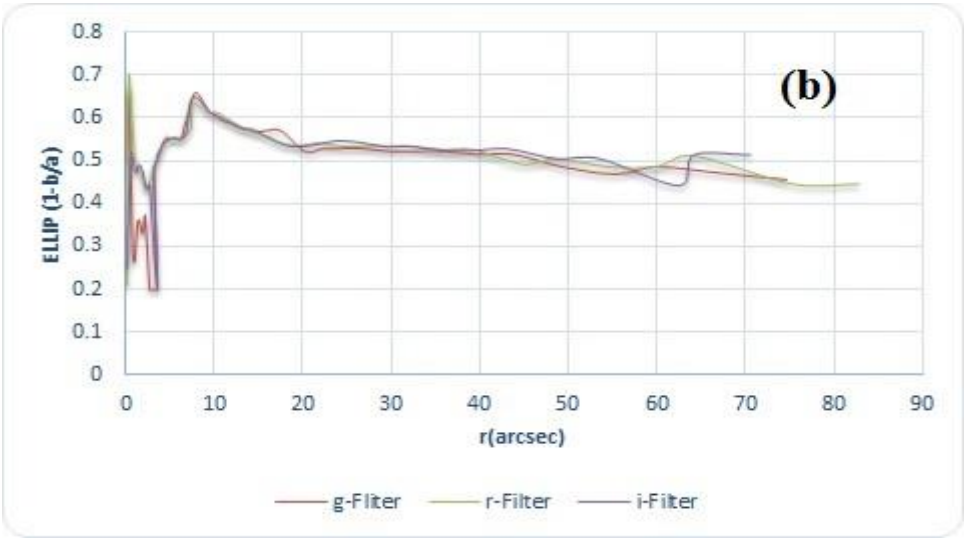


Figure 7-Ellipticity profiles of a- NGC 2577 and b- NGC 4310.

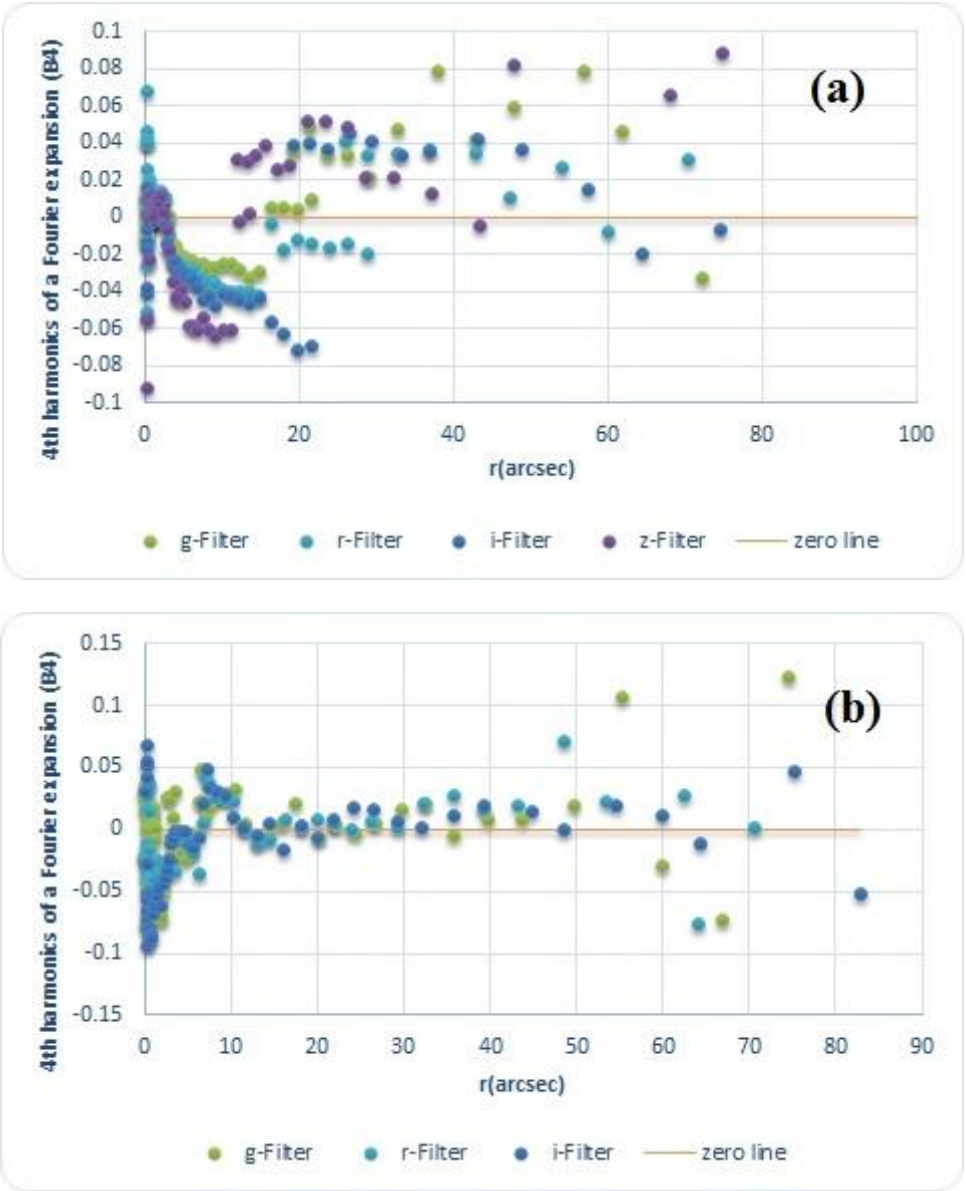


Figure 8-B4 profiles of a- NGC 2577 and b- NGC 4310.

Table 4-Isophotal position angle, ellipticity and inclination of NGC 2577 & NGC 4310.

Galaxy	Band	PA(°)	Ellipticity(ε)	Inclination(°)	B4
NGC 2577	***g***	125.5±8	0.31±0.13	48.17±9.97	0.03
	r	132.7±14.6	0.27±0.1	44.07±8.7	0.009
	i	135.9±10.6	0.313±0.145	46.5±13.5	0.0
	z	126.8±10.4	0.36±0.18	49.5±18.4	0.026
	global value	130±11	0.31±0.14	47.06±12.6	0.016
NGC 4278	***g***	112.6±2.17	0.55±0.05	65.4±3.5	0.0098
	r	112.5±1.9	0.55±0.04	65.8±3.05	0.0066
	i	112.4±2	0.55±0.04	65.5±3.05	0.0085
	global value	112.5±2.02	0.55±0.043	65.57±3.05	0.0083

3.3 SB Profiles Decomposition

The surface brightness profiles of NGC 2577 and NGC 4310 galaxies have been decomposed into a bulge which described by a de Vaucouleurs profile $''r^{1/4}$ law $''$ proposed by de Vaucouleurs (1948)[13] for a good approximation (Eq.3) while the disk fitting follows an exponential brightness profile (Eq.4), using the technique of least square fitting.

$$\mu_{bulge}(r) = \mu_e + 8.3268\left[\left(\frac{r}{r_e}\right)^{1/4} - 1\right] \quad (3)$$

$$\mu_{disk}(r) = \mu_0 + 1.09\left(\frac{r}{r_0}\right) \quad (4)$$

Where, μ_e is the surface brightness at the effective radius r_e which is defined such that half of the brightness is emitted within r_e. The central surface brightness and the scale-length of the disk are denoted by μ_0 and r_0, respectively. It has to be noted that μ_0 is not directly measurable since μ_0 is not the central surface brightness of the galaxy, only that of its disc component.

The results of the decomposition and fitting, which illustrated in Figure-(9,10) of ***gri*** and ***z*** bands, denoted that the bulge extended from the center to about 21" for NGC 2577 and 32" for NGC 4310 and the disk extended to about 72" for the NGC 2577 and 75" to the NGC 4310 and the results are summarized in Table 5 and 6. Freeman (1970)[14] distinguish two types of luminosity profile for the exponential disks, from gathering the dynamical and observational information, therefore, and from the results obtained from the fitting, the surface brightness profile of the two galaxies shows that the outer disk is of type II Freeman.

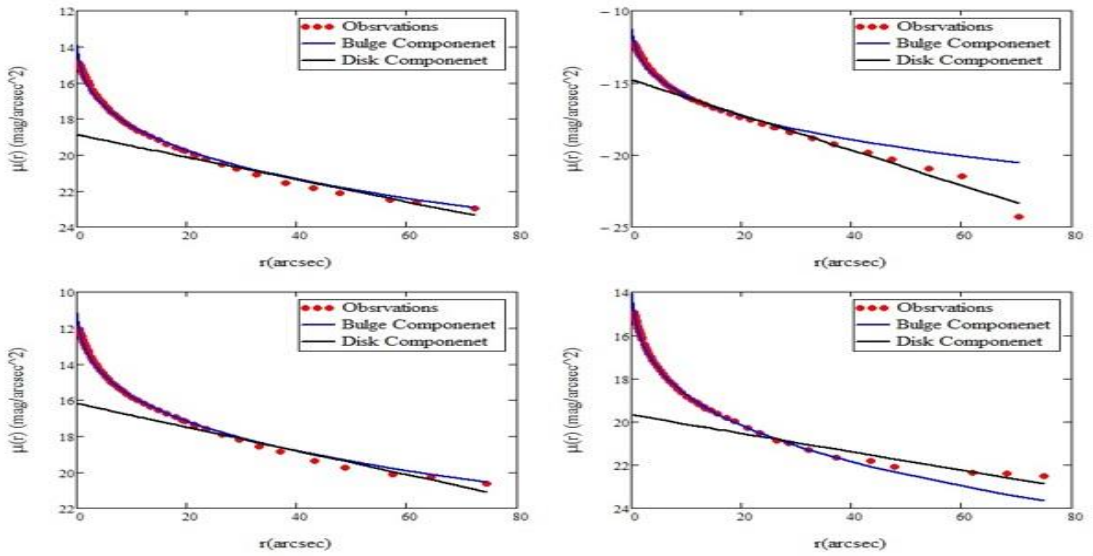


Figure 9-Decomposition of SB-profiles of **griz**-bands between Bulge & Disk model and the observed data for NGC 2577 galaxy. **griz**-bands from upper left to right.

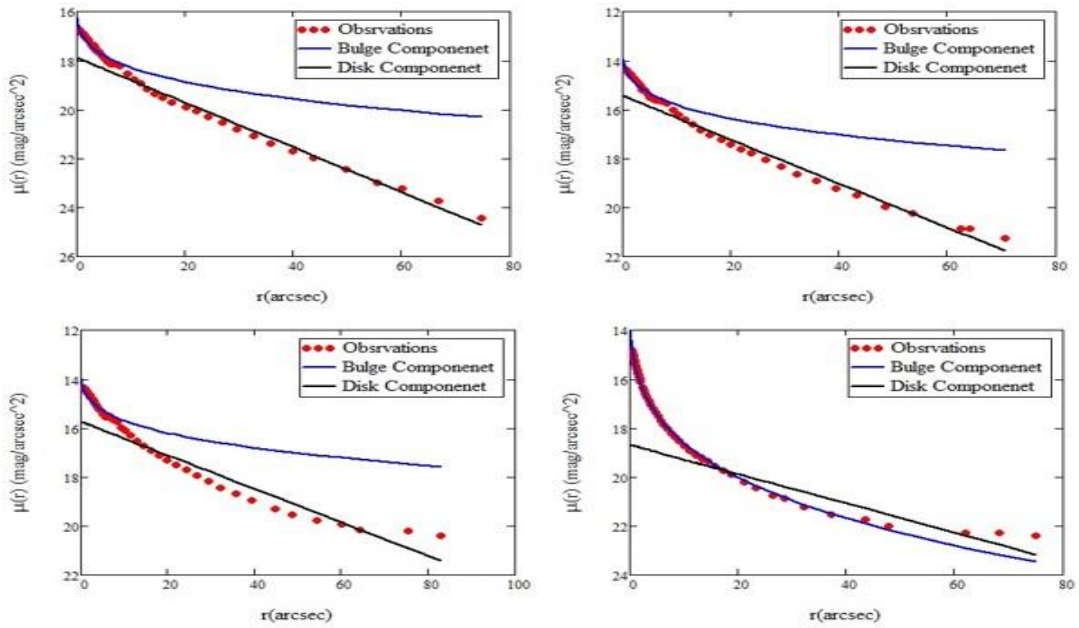


Figure 10-Decomposition of SB-profiles of **griz**-bands between Bulge & Disk model and the observed data for NGC 4310 galaxy. **griz**-bands from upper left to right.

Table 5-SB-profiles decomposition parameters of NGC 2577 & NGC 4310.

		Bulge				Disk				
	Band	**range (arcsec)**	**μ_e (mag/arcsec^2)**	**r_e (arcsec)**	**Standared error**	**μo (mag/arcsec2)**	**r_o (arcsec)**	**Standared error**	**LB_T (mag)**	**B/D**
NGC 2577	***g***	0.5-21.7	19.7	19.2	0.046	18.89	17.55	0.106	9.86	1.11
	r	0.5-21.66	16.87	16.34	0.043	14.8	8.9	0.162	7.412	0.95
	i	0.49-21.7	16.8	16.77	0.034	16.19	16.5	0.11	7.3	1.12
	z	0.5-17.2	19.6	15.36	0.028	19.69	25.54	0.12	10.28	0.74
NGC 4310	***g***	0.16-32.6	23.03	166.3	0.14	18.63	14.06	0.018	8.5	4.6
	r	0.4-32.24	20.17	112.2	0.114	16.6	16.09	0.03	6.53	3.4
	i	0.3-32.2	20.3	139.9	0.118	15.7	17.69	0.076	6.2	3.45
	z	0.5-32.15	19.5	15.3	0.03	20.8	49	0.04	10.19	0.67

4 CONCLUTION

From the results of our work we conclude that:

1- The lenticular galaxy NGC 2577 is a disky system with a bright bulge with no evidence to any bar beyond the bulge, the galaxy has a symmetrical shape with the brightness decreases at the disk, where the bared lenticular galaxy NGC 4310 is a faint disky system with three components, a faint nucleus component with non symmetrical bar shape and faint disc component.

2- From the photometric parameters, the lenticular galaxy NGC 2577 tilted with approximately 130° from the North, with semi-elliptical shape, with a disk inclined to abut 47º, while the barred elliptical galaxy NGC 4310 is tilted with 114° from the North, with semi- spherical shape, and the disc is inclined to about 66º. From the 4th harmonic of a Fourier expansion (B4) the general trend of the two galaxies is a disky system.

3- From the results of the decomposition and fitting, we found her that the type of the luminosity profile for the outer discs of the two galaxies is of type II Freeman.

5 ACKNOLEDGMENT

We are beholden to all the Organizers of the Sloan Digital Sky Survey (SDSS); from we obtained the observations, and beholden to all the persons whom teaching us.

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