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Surface Photometry of NGC 3 Lenticular Galaxy

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Abstract

Lenticular galaxy NGC3 has been chosen to study the surface photometry using griz filter. The data were obtained from the seventh Sloan Digital Sky Survey (SDSS) Data Release seven (DR7), and mainly the image reduction was done by the pipeline of SDSS. The work was achieved by the ELLIPS task from the STSDAS ISOPHOTE package in the Image Reduction and Analysis Facility (IRAF). The overall structure of the galaxy (a bulge, a bar, isophotal contour maps, together with a bulge to disk decomposition of the galaxy images) were achieved. Also, the photometric properties (the disk position angle, ellipticity, B4 and inclination of the galaxy) were estimated.

Keywords: Lenticular Galaxy, Ellipse Task, Surface Photometry, and NGC 3.

قياس اللمعان السطحي للمجرة العدسية NGC 3

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الخلاصة

في هذا البحث تم اخذ القياسات الضوئية السطحية المفصلة للمجرة العدسية NGC3 باستخدام المرشحات griz. اخذت البيانات من الاصدار السابع (DR7) لموقع Sloan Digital Sky Survey (SDSS), عولجت الصور الرئيسية بواسطة الاجراءات الرئيسية للـ SDSS. تم انجاز العمل بواسطة ELLIPS task داخل حزمة STSDAS ISOPHOTE من برنامج الـ (IRAF). تم دراسة التركيب العام للمجرة ومنها (النتوء والبار وكذلك الخريطة الكونتورية بالاضافة الى نسبة النتوء الى القرص), وكذلك الخصائص الفوتومترية (زاوية موقع القرص المجري, الاهليلجية, عامل كيرشوف الرابع B4, والميل عن اتجاه خط الرؤية للمجرة ايضا).

Introduction

Surface photometry is one of the oldest techniques in the modern astronomy used to determine the surface brightness of extended objects such as galaxies and ionized hydrogen regions. The data from surface photometry are usually combined with those from kinematical observations to yield useful results and information about the structure, formation, and evolution of galaxies [1].

From surface photometry in several pass bands we can derive the colors of galaxies which provide information about the ages and the metal content of the stellar populations in the galaxies by using stellar population models [2].

SDSS Data Release seven (DR7) is an spectroscopic and imaging scanning of the celestial sphere[3] utilizing a devoted wide-field 2.5m optical telescope, in New Mexico, Apache Point Observatory[4].

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NGC 3 galaxy was in Pisces constellation (The Fishes). NGC 3 also known as ARAK 1, CGCG 408-35, IRAS 00047+0801, MCG 1-1-37, PGC 565, UGC 58 according to HyperLEDA and NASA/IPACK Extragalactic Database (NED). NGC3 was possibly a lenticular galaxy, High-surface-brightness galaxy [5], with a classification of S0 [6]. In this paper, The sections have been arranged as follows, at begging data reduction and method will explain, also, morphologies behavior and contour map of NGC 3 ... will present, and then, the results and discussion will be presented and finally, the conclusions of this work will be summarized.

Data Reduction and Methods

In this technique, the fitting of the lenticular galaxy's isophotes to ellipses was achieved by using the ELLIPS task in the (STSDAS Library) in the Image Reduction and Analysis Facility (IRAF)[7]. The radial profiles of galaxy's surface brightness, ellipticity of the galaxy, position angle of the major-axis and the parameter for isophotal shape (B4) can be determined after fitted the isophotal shape of the lenticular galaxy's isophotes to ellipses. Surface photometric analysis was applied by fitting elliptical contours to each sky-subtracted galaxy image.

Some steps were done before the fitting process [8]:

1. Each pixel convert to arcsec (where 1 pixel = 0.396" for the Apache Point Observatory).
2. Dividing by the exposure time value (the value is the same for all filters, it equals to 53.907456 sec).
3. The counts to standard SDSS photometric system were converting by using the zero points, airmass, and extinction coefficient terms.

Morphologies Behavior and Contour Maps of NGC 3

Figure-1 shows the griz images of the NGC 3 galaxy. The NGC 3 galaxy has a disk shape of diameter about 40". The bulge is surrounded by a circular faint disk. The griz isophotal contour maps of NGC 3 are shown in Figure-2 which reveals the presence of a disk structure. The surface brightness levels of galaxy are listed in Table-1.

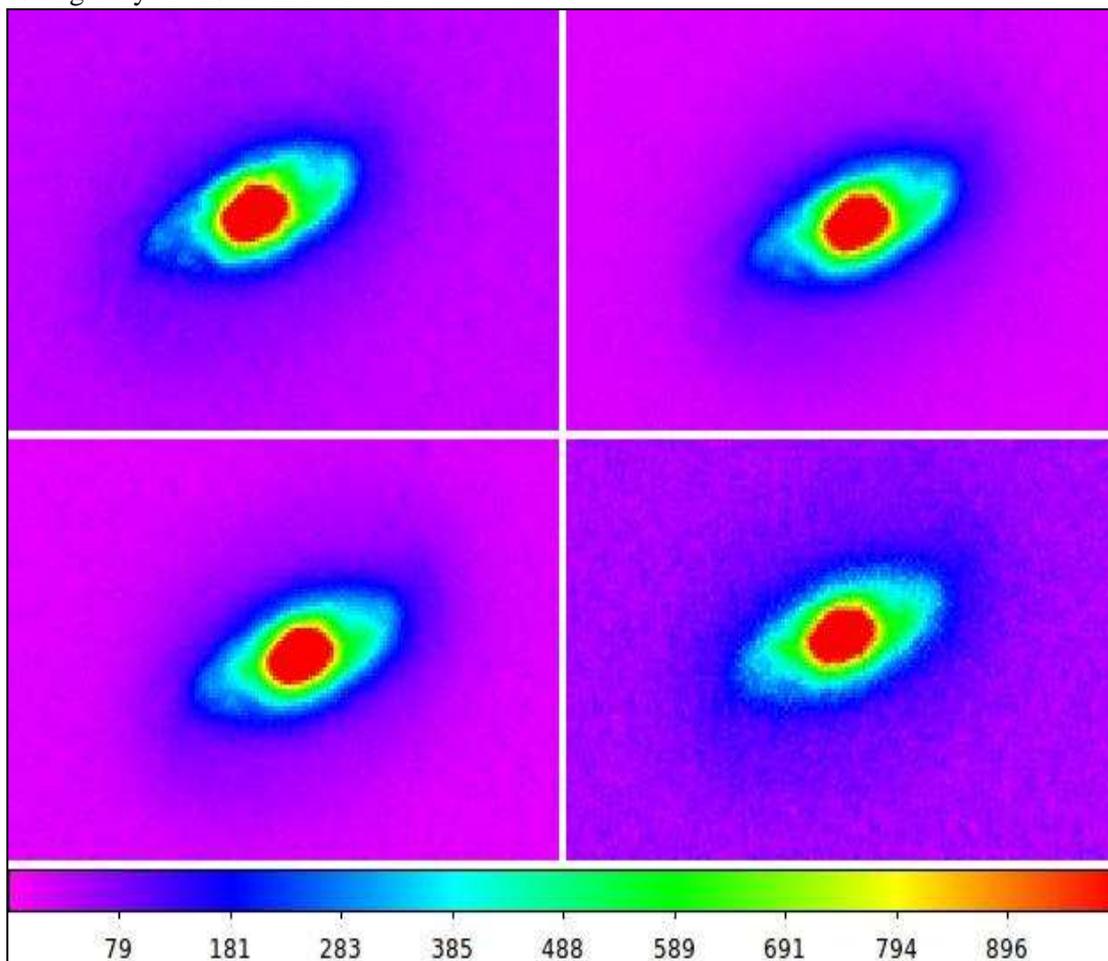


Figure 1-Color images with a griz -filters of NGC 3. North is up and East is at left.

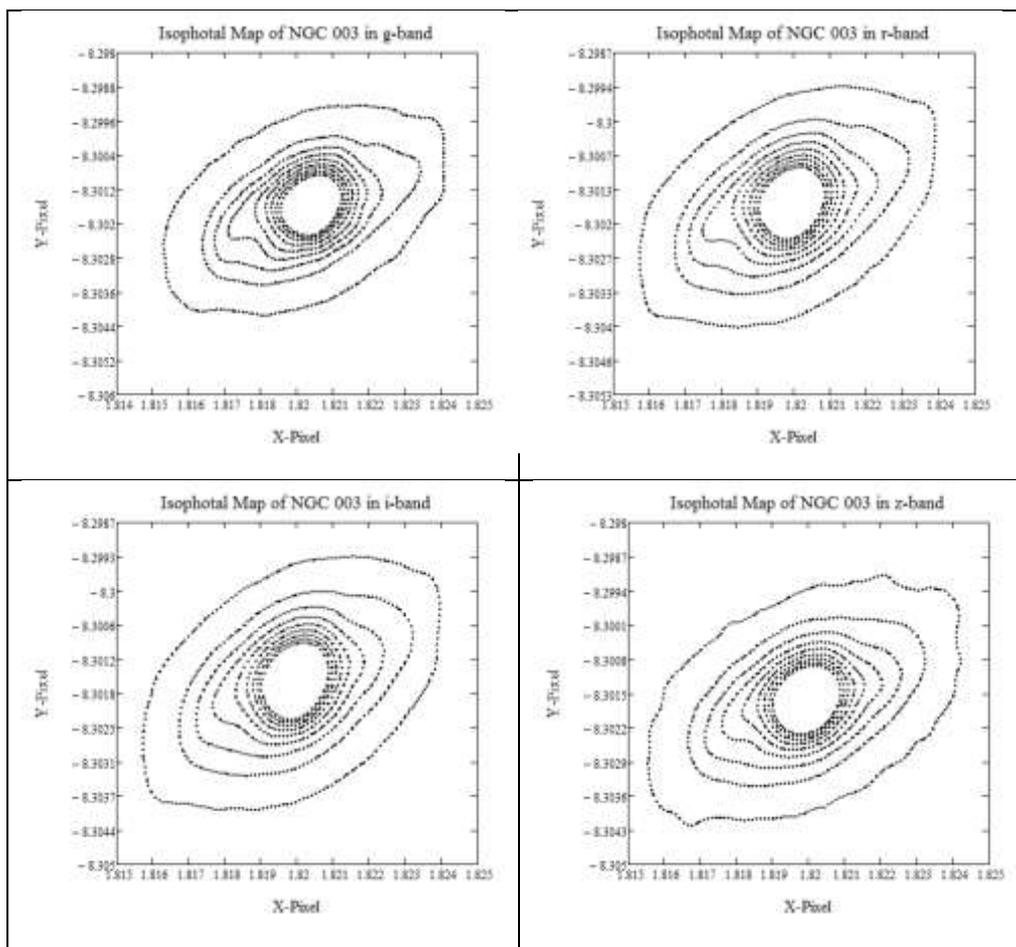


Figure 2-Isophotal contour maps of NGC 3 in griz filters, North is up and East is at left.

Table 1-The SB of the outer isophot, and the step between successive isophotes in each band for NGC 3

Band	SB(mag/arcsec ²)	Step(mag/arcsec ²)
g	22.43	1.055
r	21.33	0.88
i	20.91	0.86
z	20.7	0.91

Results and Discussion

a- Structural Profiles of NGC 3

The photometric properties, the disk position angle (PA), ellipticity of galaxy ($\epsilon=1-b/a$), and the shape parameter (B4) of galaxy are estimated as a function of the radial distance from the center of the galaxy (r), and shown in Figures(4.3a, 3b, and 3c). It shows a symmetrical behavior in the various bands.

The disk position angle (PA) increases gradually from 121° at r=4" up to roughly 125" inside the bulge of galaxy and outer the nucleus of galaxy, then it becomes more or less to 111° at 22"), then it increase to about 125° (Figure-3a, and Table-2).

At the inner 4" region the ellipticity profiles of galaxy (see Figure- (3b)) of NGC 3 rise from 0.32 to 0.55 at 7", where, in the disk region ($r > 17''$) the ellipticity of galaxy becomes 0.34 as a mean value. The inclination of the disk of NGC 3 determined by used this mean value, which is around (0.43 ± 0.09) , in Eq. (1), and the result of Eq. 1[9] showed that the NGC 3 galaxy inclined about 60 degrees.

$$\cos^2 i = \begin{cases} \frac{(1 - \epsilon)^2 - 0.2^2}{1 - 0.2^2} & \text{if } \epsilon \leq 0.8, \\ 0 & \text{otherwise.} \end{cases} \quad (1)$$

The parameter for isophotal shape B4 (Fourth harmonic of the Fourier expansion) profile showed in Figure-3c, and listed in Table-2, indicate that the NGC 3 galaxy is diskly.

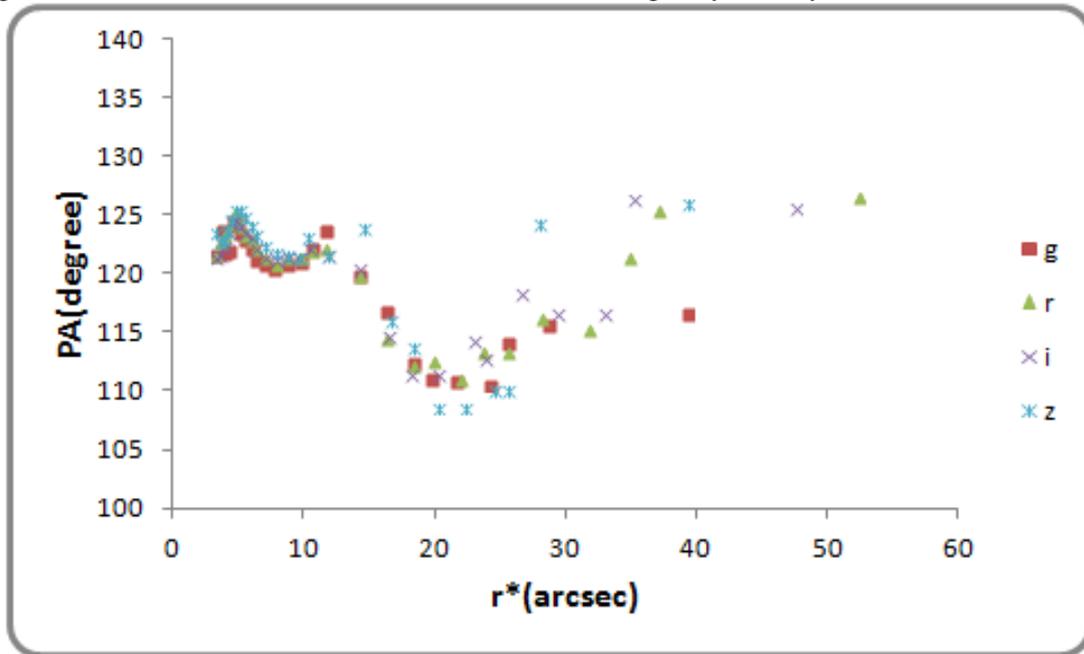


Figure 3a-Position angle of NGC 3 in g, r, i and z-bands.

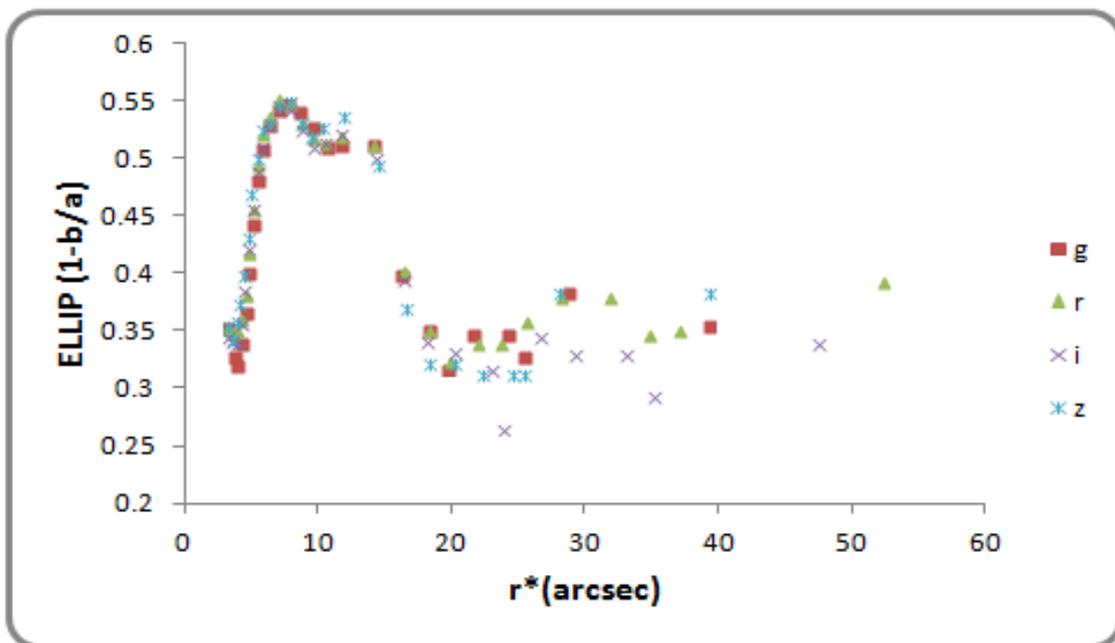


Figure 3b-Ellipticity profiles of NGC 3 in g, r, i and z-bands.

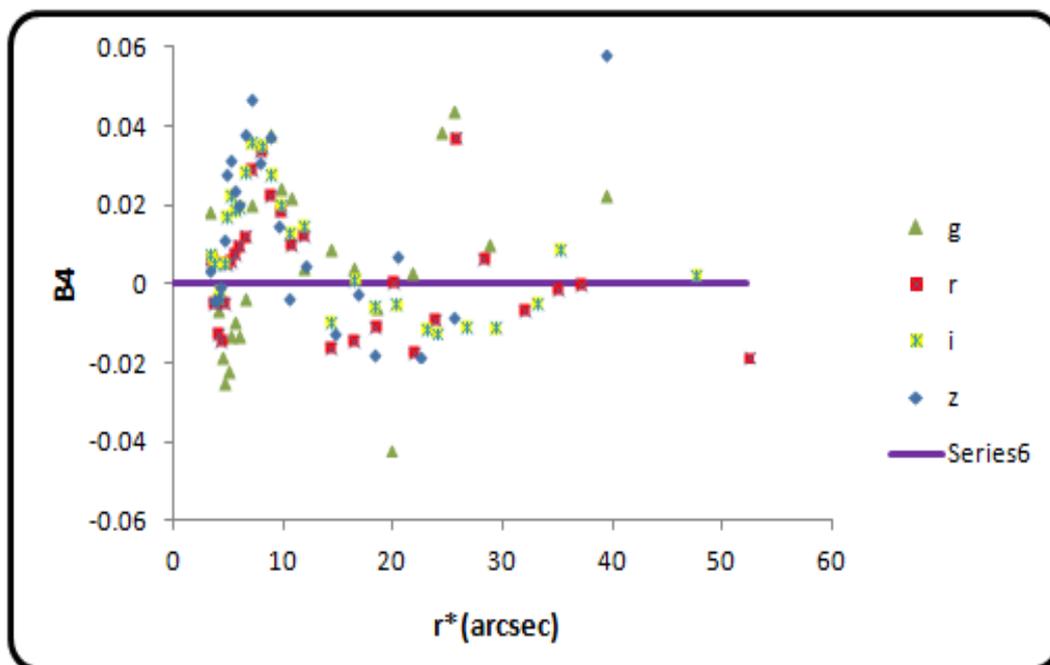


Figure 3c-B4 profiles of NGC 3.

Table 2-The Isophotal position angle, ellipticity, inclination, and B4are listed for NGC 3.

Band	PA(°)	(ε=1-b/a)	Inclination(°)	B4
g	113.4	0.426	60.8	0.02
r	114.3	0.424	60.7	0.00004
i	114.5	0.413	60.5	-0.01
z	114.6	0.429	60.8	0.0025

b- Decomposition of NGC 3

The least square fitting technique was used to decompose the griz luminosity profiles into the bulge, by using equation and disk of galaxy by using equations (2) and (3).[10]

$$\log \left[\mu \frac{r}{\mu_e} \right] = -3.33 \left[\left(\frac{r}{r_e} \right)^{\frac{1}{4}} - 1 \right] \tag{2}$$

$$\mu(r) = \mu_0 \exp(-r/r_0) \tag{3}$$

The outputs of the decomposition are listed in Table-3, and also illustrated in Figure-4 of griz bands. Freeman (1970) distinguished two types profile for the exponential disks [11], and from the results; the luminosity of griz filters explained that the disk of NGC 3 is of type II Freeman.

Table 3-NGC 3 Galaxy bulge and disk fitting parameters.

Band	Range (arcsec)	Bulge			Disk				
		μ_e (mag/arcsec ²)	r_e (arcsec)	Standard error (arcsec)	μ_0 (mag/arcsec ²)	r_0 (arcsec)	Standard error (arcsec)	LB _T (mag)	B/D
g	4.23-14.2	17.9	5.08	0.036	18.7	7.4	0.18	11.02	1.94
r	5.8-25.6	15.5	4.9	0.06	19.8	47.8	0.052	8.72	0.96
i	4.2-14.3	16.5	7.8	0.036	17.22	11.69	0.161	8.6	1.66
z	4.1-10.3	16.5	2.98	0.045	18.9	13.05	0.114	10.7	0.93

Where LB_T: band total brightness, r_e: Effective radius, μ_e : Effective surface brightness, B/D: bulge to disk ratio

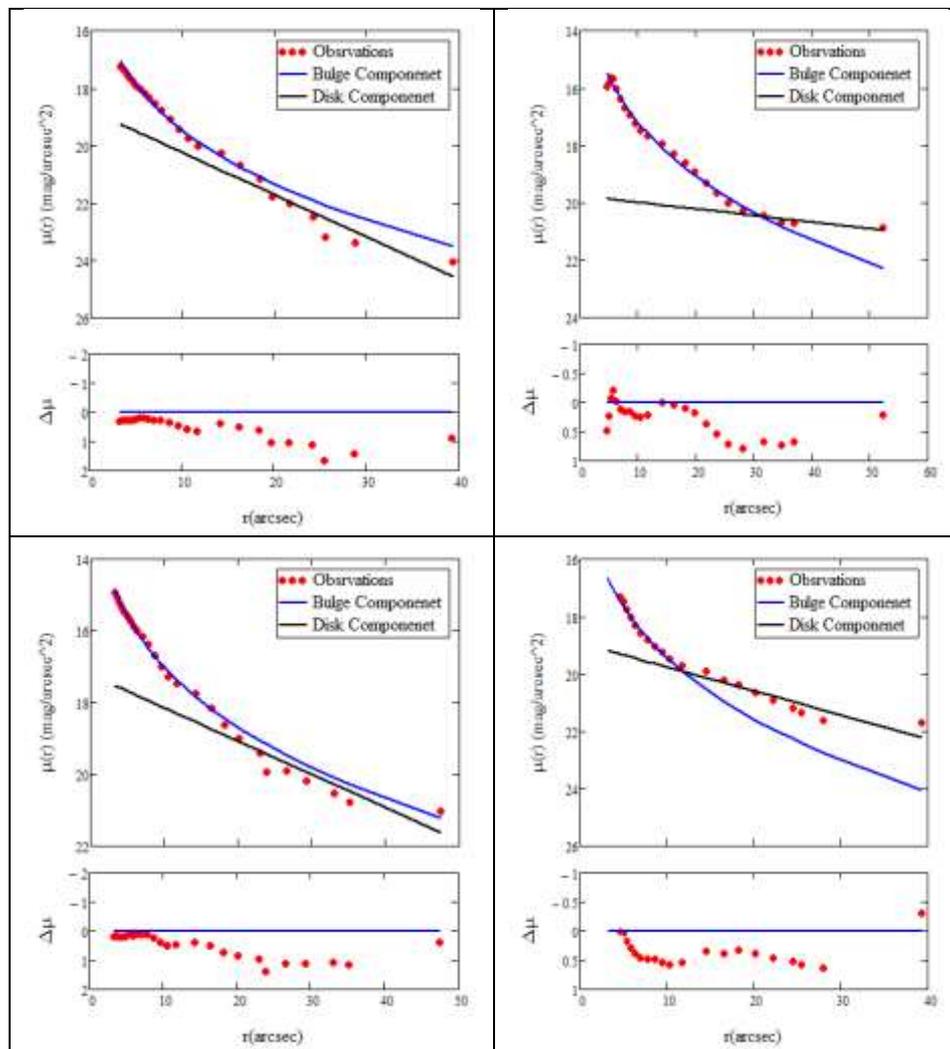


Figure 4-The Decomposition of surface brightness of galaxy of griz bands, and showed the relation between the (Bulge of galaxy + Disk of galaxy) model and the real data for NGC 3.

Conclusions

We can conclude from the results, NGC 3 galaxy has a disk shape, with a bulge surrounded by a circular faint disk; it shows a symmetrical behavior with the various bands. From the photometric parameters, the inclination of the galaxy is about 60 degree, and from the shape parameter (B4), the disk system was confirmed. After the decomposition to a disk and bulge the luminosity of griz filters explained that the disk of NGC 3 is of type II Freeman.

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References

1. Ali, G B. **1993**. Morphological and surface photometric investigation of some pairs containing UV-EXCESS galaxies. M.Sc. Thesis: Cairo University.
2. Milvang-Jensen, B. and Jørgensen, I. **1999**. Galaxy Surface Photometry. *BaltA*, **8**: 535-574.
3. York, D. G., Adelman, J. and Anderson, J. E. **2000**. The Sloan Digital Sky Survey: Technical Summary. *ApJ*, **120**(3): 1579-1587.
4. Gunn, J. E., Sigmund, W. A. and Mannery, E. J. **2006**. The 2.5 m Telescope of the Sloan Digital Sky Survey, *AJ*, **131**(4): 2332-2359.
5. Arakelian, M. A. **1975**. Galaxies of high surface brightness, *Akademiia Nauk Armianskoi SSR, Biurakanskaia Observatoriia, Soobshcheniia*, **47**: 3-42.
6. de Vaucouleurs, G., de Vaucouleurs, A., Corwin, H. G., Jr., Buta, R. J., Paturel, G. and Fouqué, P. **1991**, *Third Reference Catalogue of Bright Galaxies*, Springer, New York, NY (USA), p. 2091.
7. Jedrzejewski, R. I. **1987**. CCD surface photometry of elliptical galaxies—I. Observations, reduction and results, *MNRAS*, **226**(4): 747-768.
8. Abdullah, K. Ahmed, Arshed Ali Kadhem, and Atared Yaarub Qahatan. **2016**, Multi-wavelength studies of NGC 4425 Galaxy, *Iraqi Journal of Science*, **57**(3A): 1860-1866.
9. Lu, N.Y. **1998**. Disk galaxies in the outer local supercluster: Optical CCD surface photometry and distribution of galaxy disk parameters. *ApJ*, **506**(2): 673-685.
10. Zahraa, A H. **2018**. Study the photometric characteristic of different galaxy types. M.Sc. Thesis: Baghdad University.
11. Freeman, K.C. **1970**. on the disks of spiral and S0 galaxies. *ApJ*, **160**: 811.