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Multi-wavelength studies of NGC 4425 Galaxy

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Abstract

In this work, ugzri images of NGC 4425 galaxy are analyzed. The galaxy images are obtained from the seventh Sloan Digital Sky Survey (SDSS) Data Release (DR7). This work was performed with Image Reduction and Analysis Facility (IRAF) and analyzed the structure of the galaxy a bulge, a bar, together with isophotal contour maps and performed a bulge/disk decomposition of the galaxy image. Also, we have estimated the disk position angle, ellipticity, B4 and inclination of the galaxy.

Keywords: Galaxy, IRAF, CCD Surface Photometry, SDSS, and NGC 4425.

دراسات متعددة الطول الموجي للمجرة NGC 4425

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الخلاصة:

في هذا العمل تم تحليل صور للفلاتر ugzri للمجرة NGC 4425، وتم الحصول على هذه الصور من الإصدار السابع للبيانات (DR7) لـ (SDSS)، لقد تم إنجاز هذا العمل من خلال برنامج الـ Image Reduction and Analysis Facility (IRAF) ومن ثم قمنا بتحليل المعطيات والتركيب العام للمجرة، النتوء، البار مع الخريطة الكونتورية وكذلك مساهمة القرص الى النتوء لصورة المجرة، وكذلك تم إيجاد المعطيات الفوتومترية مثل زاوية الموقع للقرص والإهليليجية وكذلك عامل كيرشوف B4 والميل العام للمجرة.

1.Introduction:

Surface photometry is a powerful technique applied to quantitatively measure the light distribution of extended objects like galaxies, planetary nebulae, and HII regions, it is a technique rather than a distinct field of research, it can be applied with either broad or narrow band photometric systems.

SDSS Data Release (DR7) is an imaging and spectroscopic survey of the sky[1] using a dedicated wide-field 2.5m telescope[2] at Apache Point Observatory, New Mexico. Imaging is carried out in Time Delay Integrate (TDI; also known as drift-scan) mode using a dedicated camera containing 30 2048×2048 SITe CCDs[3] which gathers data in five broad bands, ugriz, spanning the range from 300 to 1000 nm[4], on moonless photometric[5] nights of good seeing. The images are processed using the specialized software, Photo, and are astrometrically calibrated[6] using the UCAC (USNO CCD Astrograph Catalog catalog)[7], and photometrically calibrated using observations of a set of primary standard stars[8] on a neighboring 20-inch telescope[9-10 and references there in].

1.1 Data Reduction

1- All images are corrected for bias and flat field by SDSS pipeline.

2- The contribution of the sky background signals is subtracted, where the sky is estimated by choosing several empty regions in the image frame far from objects and measures its mean intensity value.

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1.2 Data Analysis:

The IRAF* ISOPHOTE† ELLIPSE task is applied to obtain the intensity and structural profiles. For each intensity profile, the isophotes of the galaxy are fitted to ellipses using the ELLIPS task[11] to derive the radial profiles of surface brightness (SB), ellipticity (ε = 1-b/a, a and b are the semimajor and semi-minor axes respectively), major-axis position angle (PA measured from N through E), and isophotal shape parameter (B4). The isophotal shape, B4, parameter measures the deviation of an isophote from a perfect elliptical shape where the associated higher order Fourier coefficients from the fitting reveal whether the isophotes deviate from a perfect ellipse (B4=0) towards either a "boxy" (B4<0) or "disky" (B4>0) shape. Surface photometric analysis was applied by fitting elliptical contours to each sky-subtracted galaxy image.

The followings are done before fitting:

a. Conversion from pixel units to arcsec^2: by dividing on the scale (1 pixel = 0.396" for SDSS).

b. Normalization for exposure: by dividing on the exposure time value given in the header (the value is the same for all galaxies for all filters, it equals 53.907456 seconds).

c. We converted the counts to standard SDSS photometric system by using the zero points, airmass, and extinction terms given in the "tsField" FITS tables, available in SDSS website, corresponding to each band for each galaxy by multiplying the counts by the factor f where:

$$f = 10^{0.4(z_p + k*airmass)} \quad (1)$$

where z_p and k are the zeropoint magnitude and the atmospheric extinction, respectively (http://www.sdss.org/dr5/algorithms/fluxcal.html).

d. Conversion to magnitude units by the well known formula:

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

2. The galaxy NGC 4425

2.1 Review

NGC 4425 is a highly inclined galaxy without much dust. The SAURON (Spectrographic Areal Unit for Research on Optical Nebulae) reconstructed intensity image reveals a boxy bulge component. The two ansae emerging from the box-like (bar-like?) center of NGC 4425, seen in the insert, are not symmetrically placed along the major axis but emerge on opposite sides of the major axis, similar to features in the very-early-type S0/a galaxies, such as NGC 1380[12] . The classification of NGC 4425 in the Virgo Cluster Catalog is SBa with no peculiarities. The type in the RSA2 is SB0 pec; it is SB0 (uncertain, spindle) in the RC2 [13].

2. 2 Morphology and Contour Maps of NGC 4425

The galaxy has a boxy bulge component of diameter about 24" with a bar-like, as shown in Figure-1. The bulge is surrounded by a circular disk with 122" diameter. The ugzri isophotal contour maps of NGC 4425 are shown in Figure-2 which reveals the presence of bar-like structure. The surface brightness levels are listed in Table-1.

* IRAf is distributed by the National Optical Astronomy Observatories (NOAO) in cooperation with the Association of Universities and Research in Astronomy, Inc., in agreement with the National Science Foundation (see http://iraf.noao.edu).

† STSDAS is distributed by Space Telescope Science Institute, operated by AURA, under NASA contract (Milvang-Jensen and Jørgensen 1999).

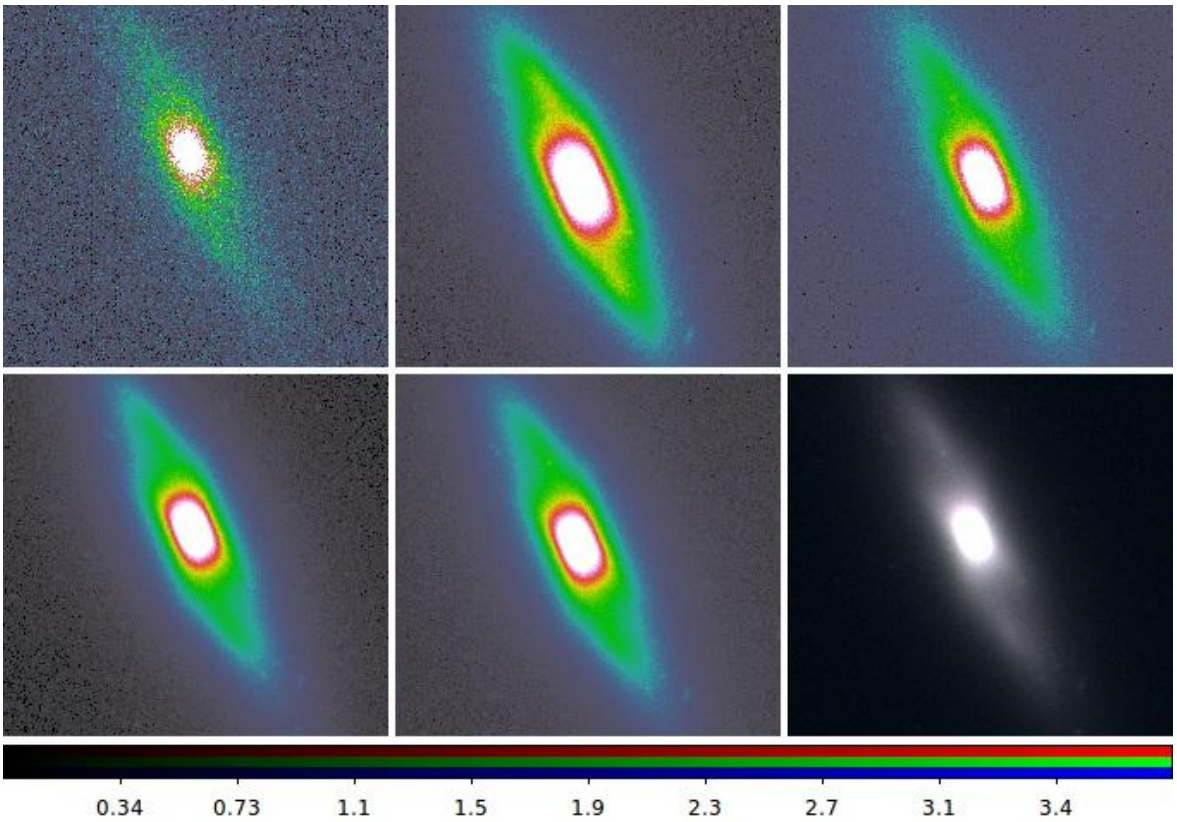

Figure 1-The ugzri-bands image and image combine of NGC 4425. North is up and East is at left.

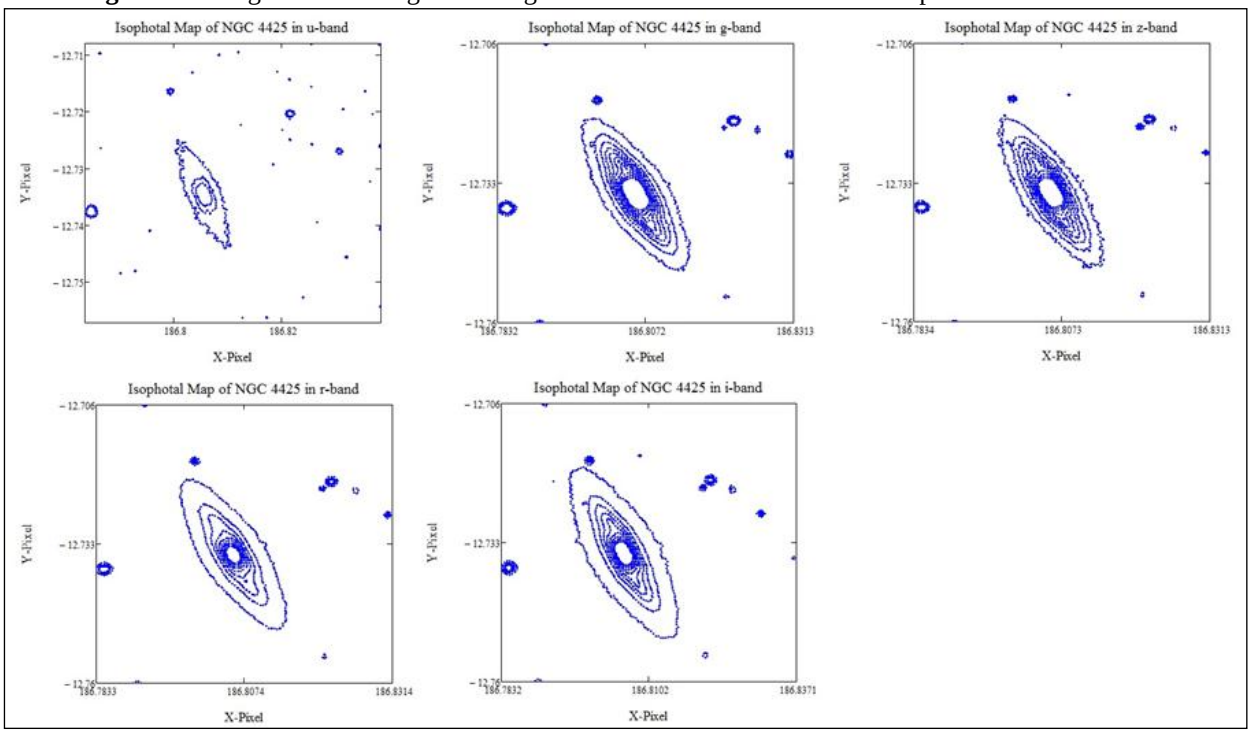

Figure 2- Isophotal contour maps of NGC 4425 in ugzri bands, North is up and East is at left..

Table 1- The SB of the outer isophot and the step between successive isophotes in each band for NGC 4425.

Band	SB(mag/arcsec^2)	Step(mag/arcsec^2)
u	23.84	1.62
g	24.75	0.74
z	21.66	0.74
r	24.43	1.23
i	24.54	1.32

3. Photometric Results

3.1 Structural Profiles of NGC 4425

The profiles of major-axis position angle (PA), ellipticity (ε ≡1−b/a) and shape parameter (B4) are obtained as a function of *r*, the distance from the center of the galaxy, and illustrated in Figures-3a, b, and c respectively. It is noticed that the profiles show more or less similar behavior and consistency in the different bands.

Within the bulge and outside the nucleus, the PA increases steeply from about 60° at r=2" up to about 67° at 27", then it becomes more or less steady to 67° at 112"), the PA is nearly steady with value of 67° Figure-3a and Table-2.

Within the inner 0.33" region the ellipticity profiles Figure-3b of NGC 4425 increase from 0.04 to 0.7 at 39". In the disk region (r > 39") the ellipticity decreases gradually outward with mean value of 0.51. The mean value of ellipticity is (0.36±0.07) used in Eq. 3[14] to calculate the inclination of the disk which is found to be 71°±5.

$$\boldsymbol{cos^2 i} = \begin{cases} \frac{(1-\varepsilon)^2 - 0.2^2}{1-0.2^2} \; \boldsymbol{if \varepsilon \leq 0.8}, \\ \boldsymbol{0} \qquad\qquad \boldsymbol{otherwise}. \end{cases} \tag{3}$$

The B4 profile illustrated in Figure 3c and presented in Table 2 shows that the general trend of the galaxy is disky.

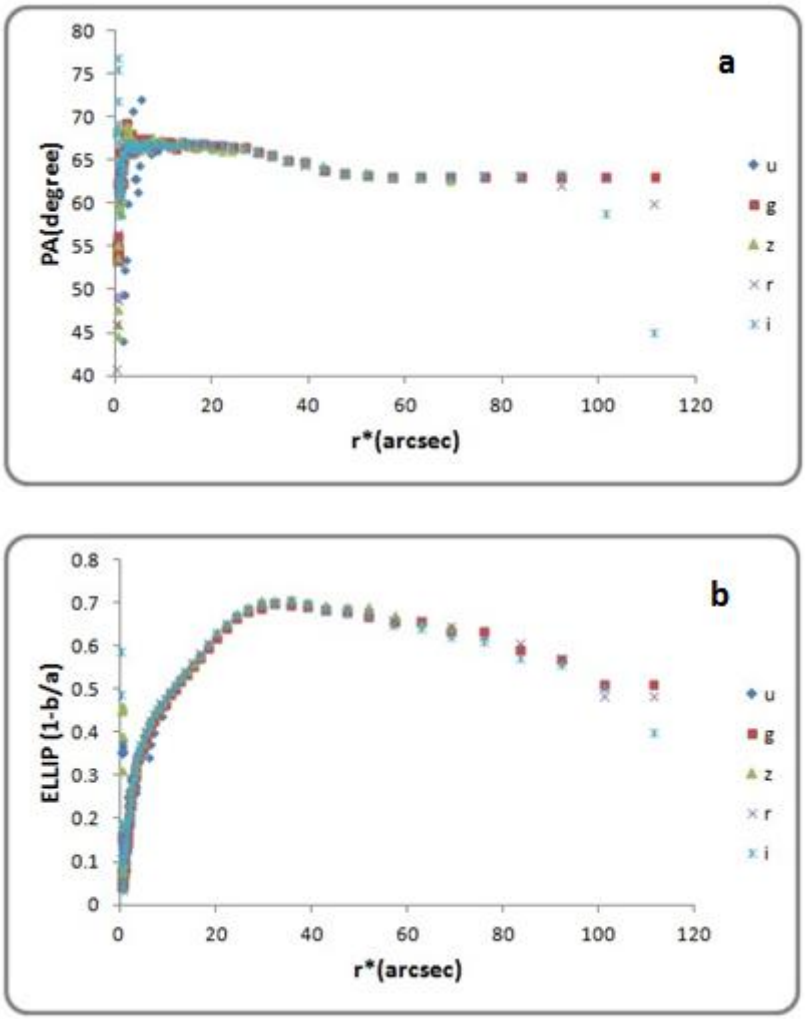

Figure 3- Structural profiles of NGC 4425 in ugzr and i-bands. (a) Position angle, (b) Ellipticity, continue…

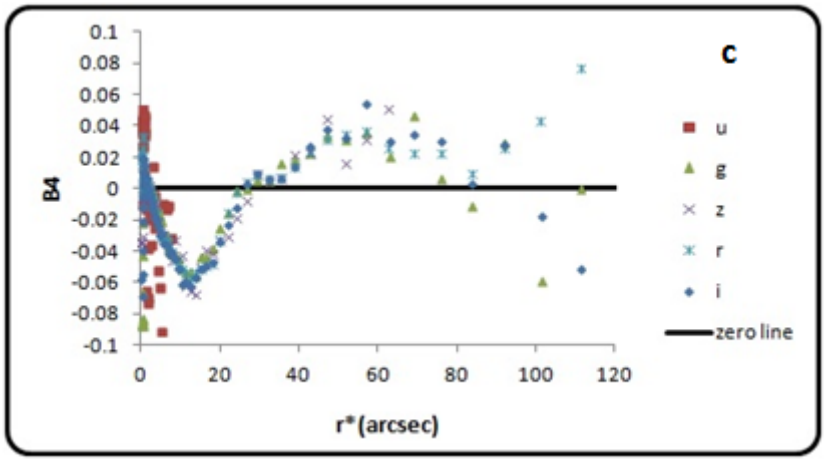

Figure 3- (c) B4 profiles.

Table 2-Isophotal position angle, ellipticity, inclination and B4 for NGC 4425.

Band	PA(°)	ε(1 – b/a)	Inclination(°)	B4
u	64.5	0.34	50	-0.01
g	67.5	0.36	76	-0.02
z	67	0.36	51	-.008
r	66.4	0.35	50.5	0
i	66.8	0.36	51.2	-0.013

3.2 Luminosity profiles Decomposition of NGC 4425

The ugzri equivalent luminosity profiles have been decomposed into the bulge ($r^{1/4}$) and disk (exponential) components using the technique of least square fitting. The results of the decomposition are summarized in Table-3, and also shown in Figure-4 of ugzri bands from upper left to right. The ugzri bands luminosity profile shows that the disk of this galaxy is of type I Freeman [15].

Table 3- Bulge and disk fitting parameters of NGC 4425.

	Bulge				Disk				
Band	**range (arcsec)**	**μ_e (mag/arcsec^2)**	**r_e (arcsec)**	**Standared error**	**μ_0 (mag/arcsec^2)**	**r_0 (arcsec)**	**Standared error**	**LB_T (mag)**	**B/D**
u	0.23-5.8	29.5	432	0.035	23.3	6.38-8.49	0.023	12.95	20
g	0.86-29	28.3	178	0.021	23.6	32-122.4	0.062	13.5	2.3
z	0.23-20	25.5	179.6	0.034	20.5	22-69.1	0.023	10.8	2.15
r	0.23-24.2	26.3	188.2	0.031	21.34	26.6-111	0.029	11.56	2.27
i	0.23-24.2	25.9	176.4	0.026	21.02	26.6-111	0.049	11.24	2.2

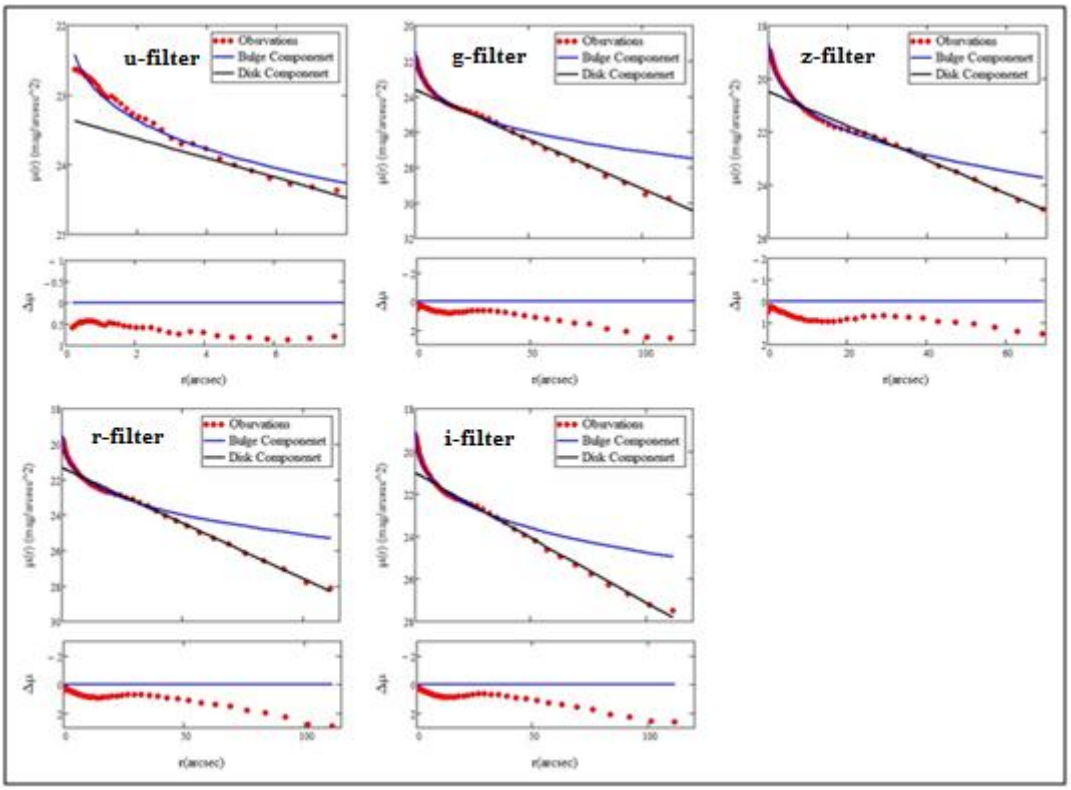

Figure 4- Decomposition of surface brightness profiles of ugzri-filters as well as the residual between the (Bulge + Disk) model and the observed data for NGC 4425 galaxy.

4. Conclusions

The galaxy NGC 4425 has a several studies, but it has not been a detailed photometric study previously. We performed here detailed photometric study. We have reported the results of multicolor surface photometry of the NGC 4425 spiral galaxy. We have analyzed the overall structure of the galaxy and performed a bulge/disk. The results of this paper included the ugzri isophotal contour maps of NGC 4425 which revealed the presence of a bar-like structure and the surface brightness levels as listed in Table-1. We found that the PA is nearly steady with value of 67° (Figure-3a and Table-2), and in the disk region (r > 39") the ellipticity decreased gradually outward with mean value of 0.51. The mean value of ellipticity is (0.36±0.07) used in Eq. 3[14] to calculate the inclination of the disk which was found to be 71°±5. Finally, the ugzri equivalent luminosity profiles have been decomposed into the bulge ($r^{1/4}$) and disk (exponential) components using the technique of least square fitting, the ugzri bands luminosity profile shows that the disk of this galaxy is of type I Freeman [15].

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