ISSN: 0067-2904
GIF: 0.851

Photometric Properties of Isolated Spiral Galaxies NGC 4800 and NGC 2715

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Abstract

We have carried out multi color CCD surface photometry on the spiral galaxies NGC 4800 and NGC 2715 using 1.88 m optical telescope of Kottamia Astronomical Observatory. From these observations, the surface brightness, Ellipticity, position angle and color indices profiles are studied. Stellar populations in different regions of the galaxies are analyzed using color indices diagrams. We found that the galaxy NGC 4800 has a diffuse bright nuclear region and the asymmetry of the bar is due to the nonuniform distribution of dust in the galaxy. The color indices of the western inner spiral arm coincide with the corresponding mean color indices of the bar indicates that the stellar population of the bar is the same as that of the western spiral arm. The brightness of NGC 2715 remains constant at limited distance along the major axis. This may be attributed to the presence of a bar whose position angle is close to that of the galactic disk. This galaxy also showed reddening, and this is due to the presence of a huge amount of dust in the bulge to disk transition zone.

Keywords: spiral galaxy, surface brightness, ellipticity. color index.

الخصائص الفوتومترية للمجرتين الحلزونيتين المنعزلتين NGC 4800 و NGC 2715

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الخلاصة

تم أجراء ارصادات فوتومترية متعددة الالوان بأستخدام كاميرا الشحن المزدوج (CCD camera) للمجرتين الحلزونيتين (NGC 4800) و(NGC 2715) وبأستخدام تلسكوب بصري قطره ١,٨٨ متر في مرصد القطاميه الفلكي. ومن خلال الارصادات تم دراسة لمعانية السطح (surface brightness) ومقدار التفلطح (ellipticity) وزاوية الموضع (position angle) ودليل الالوان (color indices). وباستخدام مخططات دليل الالوان تم تحليل الجمهرات النجمية في المناطق المختلفه للمجرتين. لقد وجدنا ان المجرة NGC 4800 لها نواة لامعة ومنتشرة وان عدم انتظام توزيع الغبار في المجرة ادى الى عدم تناظر قضيب المجرة. يتطابق دليل الالوان للذراع الحلزونية الداخلية الغربية مع نظيره للقضيب وهذا مؤشر على ان الجمهرة النجمية هي نفسها للمنطقتين. أظهر دليل الالوان لهذه المجرة انها زرقاء. اللمعان يبقى ثابتا لمسافة محددة من المحور الكبير للمجرة NGC 2715 وقد يعزى هذا الى وجود القضيب والذي زاوية موضعه قريبة من قرص المجرة وأظهر دليل الالوان لهذه المجرة انها حمراء وهذا مؤشر وجود كمية ضخمة من الغبار في المنطقة الفاصلة بين الهالة وقرص المجرة.

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Introduction

Isolated Galaxies are those that have not suffered any interaction with another galaxy of comparable size. The study of isolated galaxies is important because they can be used as comparison objects in studies of the environmental effects on galaxies belonging to groups and clusters, and they are ideal for confronting with theoretical and model predictions of galaxy evolution. Visual observation of the images of galaxies provides the most fundamental understanding of galactic structure. Our understanding of galaxy morphology first came from examination of photographic plates. Photographic surface photometry of galaxies has been one of the major branches of extragalactic studies since Hubble's pioneering work in the early 1930s. Most of the current knowledge about the structure of galaxies came from the analysis of the photographic plates. Recently, this technique has been enhanced by the replacement of digital imaging. This new technology improves sensitivity by a factor of 100 and provides greater dynamic range. The 1980s saw the rise of the CCD cameras, it is a device consists of light sensitive photoelectric cells, or "pixels", that transfer incoming light particles into electric current [1]. The pixels can also be digitally combined, which increases light sensitivity at the expense of resolution [2]. The light observed in the visual wavelengths from a galaxy arises from all its stars, with the radiation contribution from the brightest hot stars competing with the light from the more numerous fainter cool stars. In this sense, we can infer a galaxy's stellar composition and age by observing its color [3]. Photometry can be defined as the determination of the amount and temporal nature of the flux emitted by an astronomical object as a function of wavelength [4]. By taking images of a galaxy at different wavelengths, and then analyzing the intensity distribution in each image, one can determine the distribution of stars, dust, and gas within the object. In order to obtain images of objects at different wavelengths for photometric study, a series of filters are introduced into the light path of the instrument being used. In order for the resultant images to be scientifically useful, it is important that a standard set of filters be used. One such standard is the Cousins set. The set contains five filters UBVRI filters. It is not necessary to use all five filters in order to gather photometric data [5]. In this paper we use only three filters (BVR). Surface photometry is an important tool in the understanding of galaxy mass and structure. Obtaining the structural characteristics and the total luminosity of a galaxy requires knowledge of its surface brightness profile. During a surface photometry project to explore the structure of galaxies by morphological type [6]. The goal of our study is to perform detailed multicolor surface photometry of the spiral galaxies NGC 4800, NGC 2715 and its brightest star forming regions.

Observations, Data Reduction and Photometric Calibration

In this section we will concentrate on the kind of optical telescope, the processing that implied to manipulate the data and photometric calibration.

1. Observations

The observations were obtained in March 2011at the Newtonian focus of the (1.88 m) reflector telescope which has a focal length of (9.15m) at Kottamia Astronomical Observatory (KAO), Egypt. With broadband B, V, and R this CCD array realizes a photometric system close to the standard Johnson– Cousins UBVRI system. The array was cooled with liquid nitrogen. The size of the array is 1.024 x 1.024 pixels, providing an image scale of 0.305 arcsec/pixel. Table-1 illustrates an observing log.

Table 1- Log of observations

Date of observation	The name of the Galaxy	Filters	Time exposure (sec)	Seeing	airmass
2011/3/27-28	NGC 4800	B	3 x 600	1.41"	1.33
		V	3 x 600		1.36
		R	3 x 600		1.41
2011/3/29-30	NGC 2715	B	2 x 900	1.21"	1.21
		V	2 x 900		1.32
		R	2 x 900		1.29

2. Data Reduction

We performed the preliminary reduction of the images. To correct for electron bias and the effect of "hot pixels" and bad columns of the CCD array, we subtracted a dark frame that was the average of several exposures taken with a closed shutter and the same integration time as for the object. We used summed frames of the twilight sky. We divided each image by its flat field to correct for the nonuniform sensitivity of the detector pixels. We performed the subsequent data reduction using a standard procedure incorporating Astronomical Image Processing Packages software IRAF [7,8,9,10,11].

3. Photometric Calibration

The photometric calibration of the galaxies NGC 4800 and NGC 2715 were based on standard stars PG 1633+099 ' and SA 101-1' respectively; from the list of the Landolt standard stars [12] observed on the each night, the instrumental magnitudes were transformed to the standard Johnson-Cousins UBVRI system. The images of galaxies NGC4800 and NGC 2715 are recorded on CCD camera using B, V and R filters. These images are demonstrated in figure-1.

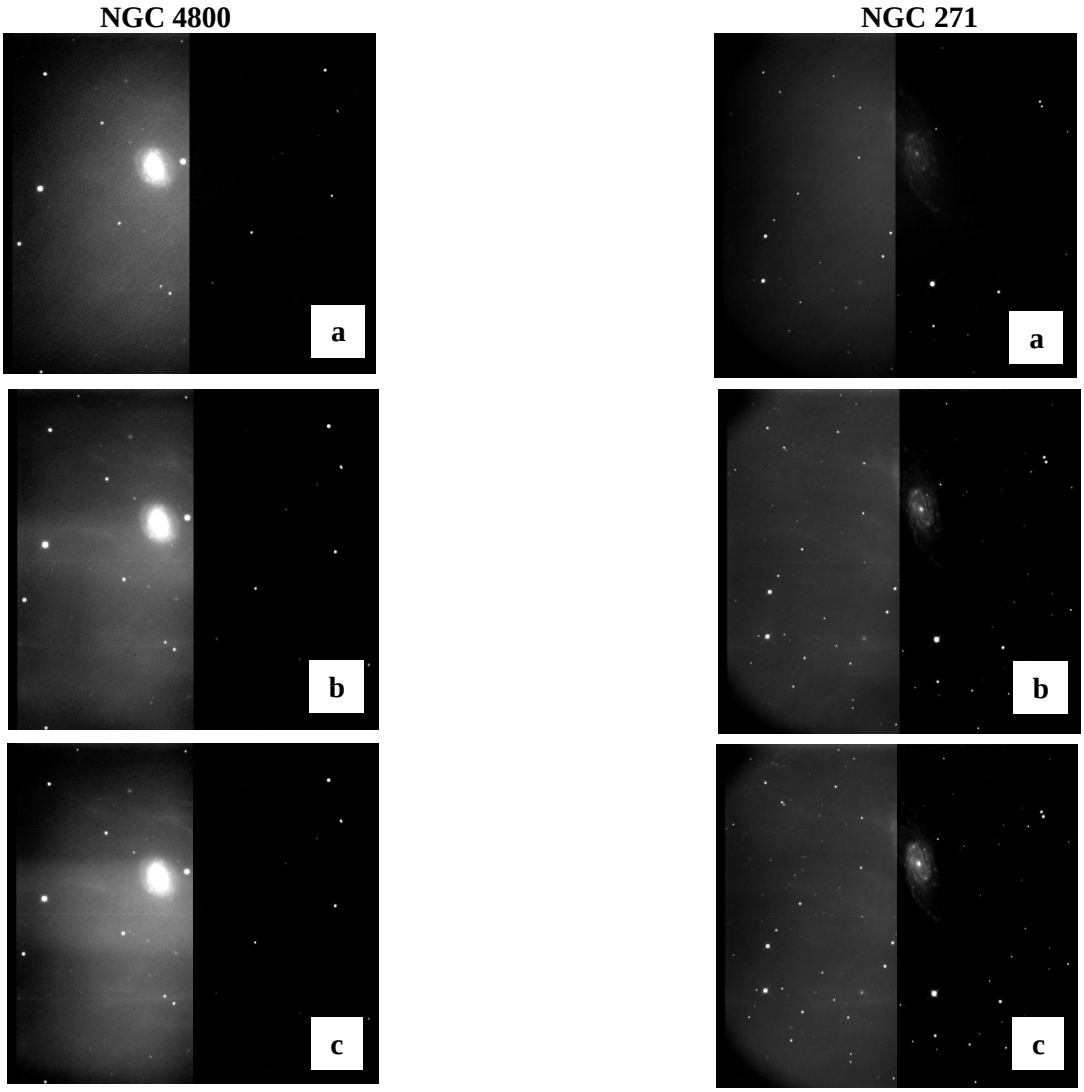

Figure-1 CCD image of NGC 4800 and NGC 2715 before reduction (a) B filter (b) V filter (c) R filter

The output of the data reduction process for the galaxies NGC 4800 and 2715 are shown in figure-2. The results illustrate a clean background.

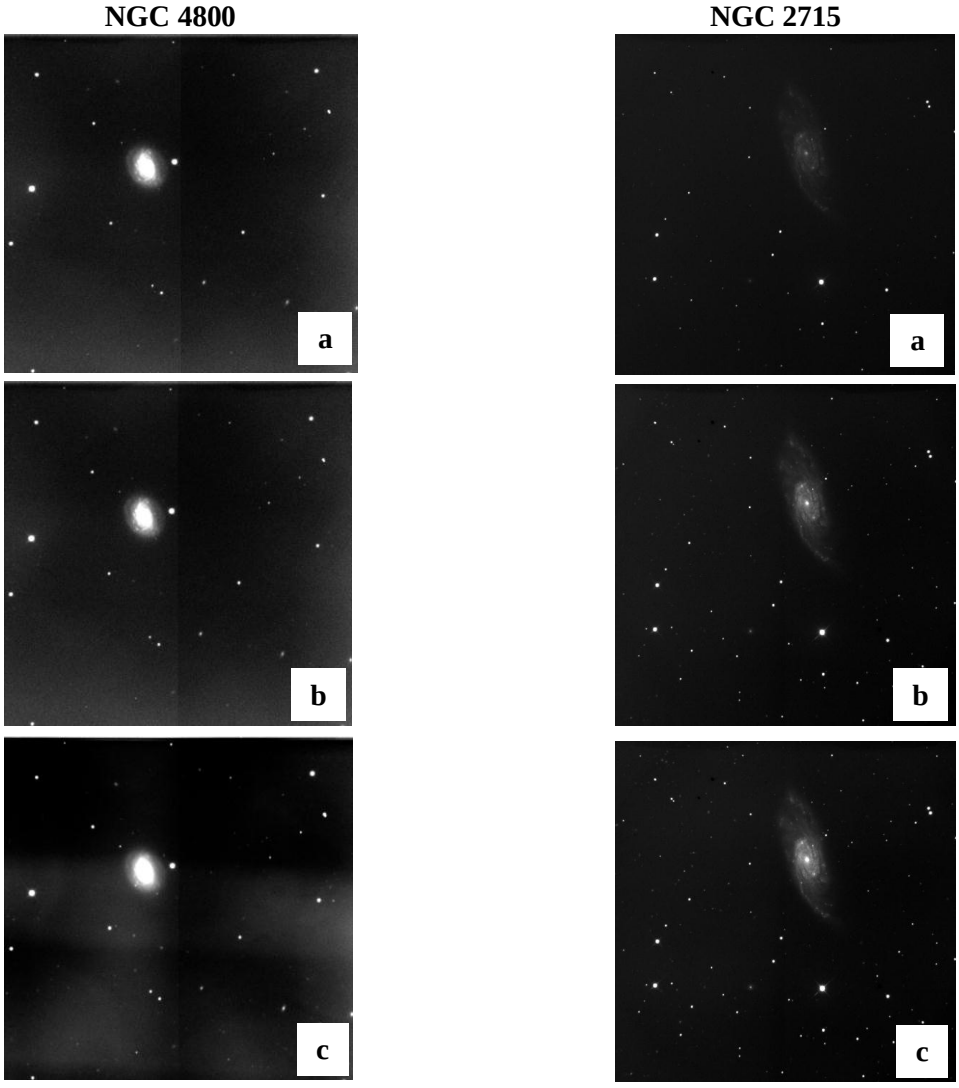

Figure-2 CCD image of NGC 4800 and NGC 2715 before reduction (a) B filter (b) V filter (c) R filter

Analysis and results

NGC 4800 is a spiral galaxy of Sb type which located in the constellation of hunting dogs. It was discovered on 1st April 1788 by William Herschel .

Figure-3 shows photometric profile along the major axis of NGC 4800 taking by B, V and R filters. The galaxy has a diffuse bright nuclear region and the diameter of the nucleus is found to be approximately 14″ which is considered to be large and the region itself is shifted to the east of the nucleus. This profile also shows asymmetry at nucleus distances of 7″ to 20″ and this in morphologically resembles an asymmetric bar. The asymmetry of the bar is due to the nonuniform distribution of dust in the galaxy.

The B and V surface brightness's of the bar to the west of the nucleus do not vary with distance and are equal to 20.8 ± 0.2 m/arcsec^2 in V. In R filter the brightness decreases far away from the galactic center, which mean that the fraction of young stars increases toward the tip of the bar [13]. The observed structure of the bar east of the nucleus is complex and it has smearing with a radius of 8″.

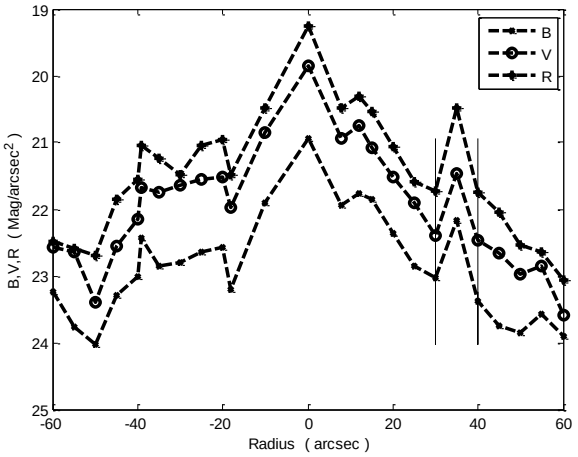

Figure 3- Photometric profiles along the major axis of NGC 4800.

Figure-3 also shows the arrangement of the arms indicated by black lines the northwestern part of NGC 4800 (r = 40″ to 20″) passes nearly along the western spiral arm (m_v= 21.65 ± 0.15 m/ arcsec^2), while the section made through the southeastern part of the galaxy (r = 20" to 40") crosses the inner disk (m_v = 22.1 ± 0.2 m/ arcsec^2). The brightness of the outer disk decreases exponentially on a scale of (20.6″ ± 0.7″) in V. The brightness in the region r = 12″ to 28″ occupied by the inner disk sharply decreases exponentially, on a scale of (19.4″ ± 1.0″) in V. The maximum surface brightness at the galactic center are (m_B = 20.9 m/ arcsec^2, m_v = 19.8 m/ arcsec^2 and m_R = 19.2 m/ arcsec^2). Two spiral arms emerge from the bar ends in the western and eastern parts of the galaxy. A decomposition of the central region of the galaxy into the inner disk and bulge shows that the brightness decreases in accordance with a de Vaucouleurs law.

The dependence of the position angle and ellipticity on the radius from the center of the galaxy is presented in figure (-4a), (-4b). The isophotes of NGC 4800 started from the center up to r = 20″ and are nearly circular. The position angle PA= 10°± 5° and the isophotal ellipticity is sharply increases at r = 20″. For more distant regions, the e(r) and PA(r) dependences are affected by the spiral arms brightness.

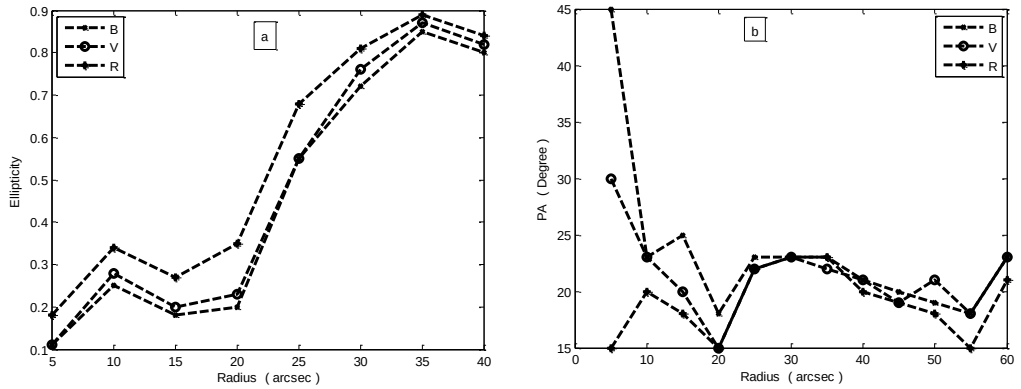

Figure 4- (a) Isophote ellipticity (b) position angle of the galaxy P A as a function of the distance *r* to the center of NGC 4800

The profiles of the B−V and V-R color indices along the radius are shown in figure-5. The galaxy as a whole is blue. The integrated color indices at the core are B − V = 1.1± 0.1mag and V – R= 0.6 ± 0.02 mag. The corresponding indices at the edges are B − V =0.7 ± 0.1mag and V – R= 0.1 ± 0.03 mag. The bar of the galaxy becomes bluer toward its periphery. Its color indices decrease from 1.1 ± 0.01 mag to 0.70 ± 0.01 mag in B−V, from 0.70 ± 0.01 mag to 0.20 ± 0.01 mag in V –R. The color indices of the western inner spiral arm coincide with the corresponding mean color indices of the

bar.This indicates that the stellar population of the bar is the same as that of the western spiral arm (the region located within (20″) of the center).

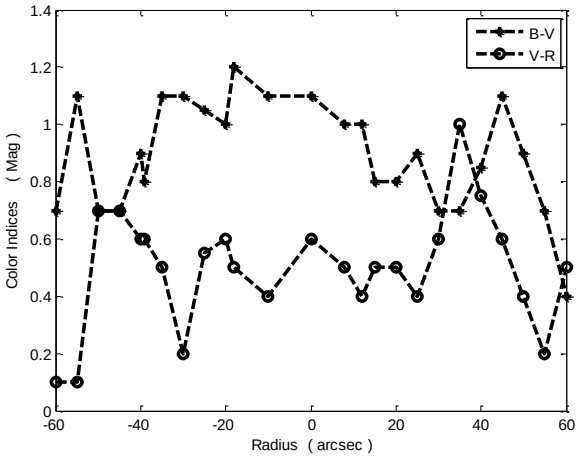

Figure 5- Profiles of the color indices along the major axis of the galaxy NGC 4800

NGC 2715 is spiral barred galaxy located in the constellation Camelopardalis. It is considered a grand design barred spiral galaxy and is classified as strongly inclined SABc galaxy, meaning that the galaxy's arms wind moderately (neither tightly nor loosely) around the prominent central bar.
Figure-6 illustrates B, V and R the photometric profile along the major axis is symmetric around the center. The brightness remain constant at the distance r = 20″ - 40″ along the major axis this may indicate presence of a bar whose position angle is close to that of the galactic disk. The surface brightness at the core are (m_B= 16.4 m/arcsec^2, m_V = 16.6 m/ arcsec^2 and m_R= 17.4 m/ arcsec^2). Spiral arms emerge from r = 34″. The surface brightness reaches m_V = 21.1 m/ arcsec^2 in the northeastern and southwestern parts of the spiral arm.

The dependence of the position angle and ellipticity on the radius from the center of the galaxy is presented in figure (-7a), (-7b) respectively .The position angle and ellipticity values derived from the isophotes in the different bands are generally in good agreement. The only exceptions are the position angles obtained for the disks this is due to the fact that this galaxy is observed nearly face-on, and in addition, a well developed spiral structure with numerous star forming regions. Within the inner r= 10" the ellipticity profiles of the galaxy fluctuate, followed by a small increase till r =23" and then became nearly flat in the outer parts then sharply increasing at r = 50". Also the position angle smoothly fluctuated from the center till r =30" rapidly decreases and then from r = 45" up to the outer in the region of spiral arms of the galaxy become more stable.

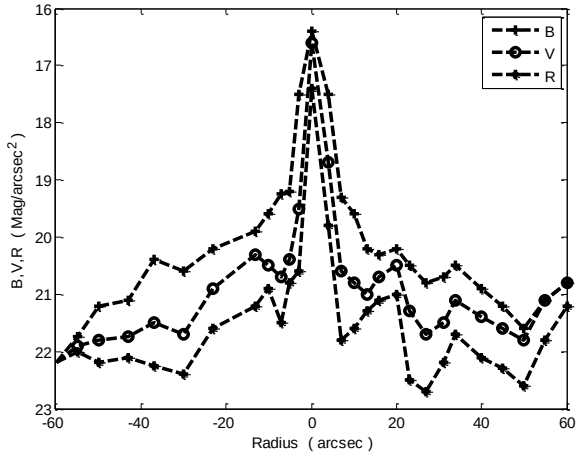

Figure 6- Photometric profiles along the major axis of NGC 2715

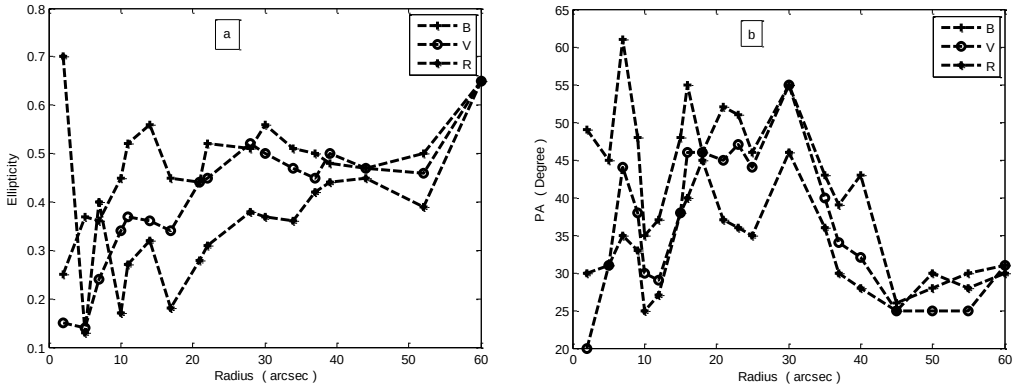

Figure 7- (a) Isophote ellipticity (b) position angle of the galaxy P A as a function of the distance *r* to the center of NGC 2715

Figure-8 demonstrate the radial profile of the color index of the (B-V) and (V-R) along the major axis of NGC 2715. This galaxy has a normal color distribution where the nuclear region r ≤ 15" is red with B-V=1.18± 0.01 mag and V-R=0.7± 0.01 mag, at the periphery of the galaxy B-V=0.3 ± 0.01 mag and V-R=0.2± 0.05 mag. The color index for the bulge are B-V=0.6± 0.1and V-R=0.36± 0.25 but for the bars are B-V=0.59 ± 0.01 and V-R=0.1 ± 0.01.

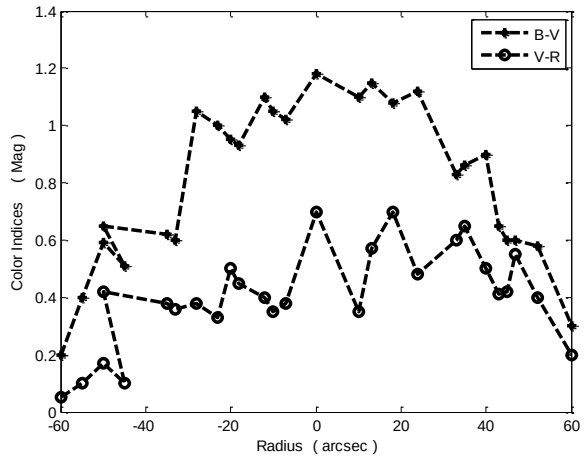

Figure 8- Profiles of the color indices along the major axis of the galaxy NGC 2715

Conclusion

The multicolor surface photometry indicates that:

1- For NGC 4800, the brightness of the outer disk decreases exponentially. A decomposition of the central region of the galaxy into the inner disk and bulge shows that the brightness decreases in accordance with a de Vaucouleurs law. The bar of the galaxy becomes bluer toward its periphery. This has been interpreted as an infall of gas toward the galactic nuclei. The stellar population of the bar is the same as that of the western spiral arm. Radial gradients have been found in the color index due to a decreasing age and metallicity toward the edge of the galaxy.

2- For NGC 2715, the radial color index shows reddening corresponding to a drop in luminosity, which occurs in the radial surface brightness profiles. The profile also shows a huge amount of dust starting from the bulge reaching the disk transition zone.

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