

## Morphology and Photometry of the UV-Excess Galaxy Pair NGC 7770/7771

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**Abstract.** Morphology of the nuclear region of the component NGC 7770 indicates that it has a complicated structure in the B-band, while the V-band shows a double nuclear structure. The brightness and color of the nuclear condensations are given. Detailed photometric analysis of this component including luminosity profiles along major and minor scans as well as position angle and ellipticity curves is obtained. Integration and decomposition of the luminosity profiles are also performed. The color distribution and integrated color are also studied taking into account that the blue color together with the unusual color distribution are characteristics relevant to UV-excess galaxies. The integrated photometric parameters are also given.

The state of interaction between the components of the pair is also investigated. The peculiar features appearing in the isophotal maps, the truncation of the luminosity profile along the side of interaction and the unusual appearance of the structural profiles are discussed and considered as strong evidence for the real state of interaction between the components of the pair. A lower limit of the total orbital mass of the system is found to be  $M_t = 1.36 \times 10^{10} M_{\odot}$ , and the total mass-to-luminosity ratio is  $f = 0.63 f_{\odot}$ .

### 1. Introduction

This pair forms together with a third galaxy, NGC 7769, a group of triple galaxies described by Karachentsev (1987) as an isolated triple system. The components of the pair form a double system with about 1.2 separation, and embedded in a common envelop at  $B \geq 24.5$  and  $V \geq 23.5$  mag.arcsec<sup>-2</sup>. The outer envelopes enclosing the pair are clearly irregular and shredded, so according to the Karachentsev scheme of interaction signs (Karachentsev 1990) this pair could be described as a pair of shredded atmosphere with interactive class ATM(sh). According to the 21-cm observations made by Sulentic and Arp (1983), the HI profiles of NGC 7770 and NGC 7771 are classified as SA class (asymmetric profile with a single peak) and C class (complicated profile) respectively; the classes which are an indication for undergoing violent interaction. The components of the system are also included in the 3rd Kazarian list for galaxies with UV-excess, (Kazarian and Kazarian 1980). Detailed UBV photometry for this system was made by Tamazyan (1984) who showed that the nuclei of these galaxies are blue

objects with various degrees of ultraviolet continuum. Assuming that the components of the pair are in a circular orbit relative to each other, a rough estimate of the lower limit of the total orbital mass of the system is calculated from the relation  $M_t = 32r_p(\Delta v)^2 / (3\pi G)$  (Karachentsev 1990), where  $r_p$  is the projected separation,  $\Delta v$  is the velocity difference between the components and  $G$  is the universal constant of gravity. The total orbital mass of the system is found to be  $M_t = 1.36 \times 10^{10} M_\odot$  while the total mass of the system NGC 7769/7771 was estimated by Karachentsev (1987) to be  $2.74 \times 10^{11} M_\odot$ . Detailed photographic B and V surface photometry is performed only for the small companion; NGC 7770; since the other component has been studied by Osman (1986). The basic parameters of the components of the pair are collected from RC3, and listed in Table 1.

Table 1. Basic data for NGC 7770 and NGC 7771, (RC3).

Parameter	NGC 7770	NGC 7771
Coordinates $\alpha$ (1950)	23h 48m 49.9s	23h 49m 52.3s
$\delta$ (1950)	19° 49' 13"	19° 50' 08"
Morph. Type	SO/a, T=0	SBa, T=1
Magnitude BT	14.40 0.30	13.08 0.05
BT	14.16	12.49
mB	14.38	12.94
mFIR		9.92
Colors (B-V) <sub>T</sub>	0.59 0.06	0.83 0.05
(B-V) <sub>T0</sub>	0.51	0.69
(U-B) <sub>T</sub>	0.34	0.09
(U-B) <sub>T0</sub>		0.26
HI Index HI		2.04
Mean HRV, Vopt	4264 52 km/sec	4298 30
Position angle		68°

## 2. Observations

Three photographic plates in each of the B and V bands have been obtained at the Newtonian focus (22."53/mm) of the 188 cm telescope, Kottamia Observatory (Egypt). The photographic calibration of the plates was performed using the Kodak calibrated step wedge on each plate (Osman 1985). The plates were scanned and measured employing the PDS microdensitometer in RGO, UK.

## 3. The Component NGC 7770

NGC 7770 (=Kaz 347 =UGC 12813 =MCG +03-60-0034) is a small close companion of NGC 7771 (Kaz 348) and is displaced about 1.2 southwest from it. It appears to be a compact galaxy with the main body of elliptical shape ( $0.18 \times 0.14$  at B=22.5 mag.arcsec<sup>-2</sup>) embedded in a faint envelop extended nearly perpendicular to the main body. Many authors have confused the morphological type of this galaxy. Pettit (1954) and de Vaucouleurs and de Vaucouleurs (1964) have classified it as SBb and Sb respectively. But de Vaucouleurs et al. (1976) have classified it as SO/a, i.e. a transition stage between late lenticular and early spirals. Egiazaryan (1983) described it as a very bright compact

galaxy measuring about  $12'' \times 16''$ , with complicated and composite spiral structure. Tamazyan (1984) has showed that it does not exhibit a developed spiral structure and classified it as SO galaxy. NGC 7770 is a galaxy with strong UV continuum of early type and spectroscopically classified as d2 by Kazarian and Kazarian (1980). Spectral observations made by Kazarian and Kazarian (1989) showed that the spectra of this galaxy cover both long and short wavelengths including emission lines of [SII]  $\lambda\lambda 6731/17$ , [NII]  $\lambda 6584$ , [OIII]  $\lambda\lambda 5007, 4959$ ,  $H_{\beta}\lambda 4861$ , and [OII]  $\lambda 3727$ .

### 3.1. Morphology of the Nuclear Region

Although the appearance of this galaxy is uniform, it has a complicated nuclear region. The B and V isophotal maps show that the structure of the nuclear region is more complicated in the B-band than in the V-band. It shows multi condensations of different sizes, with the major one off-centered and shifted towards the southwest direction. This major condensation appears to be composed of many small condensations. On the other hand, the V-isophotes show a double nuclear structure. This complicated structure of the nuclear region is also confirmed in the intensity profiles, in which there are a number of peaks representing the condensations noticed along the adopted major (p.a. $\simeq 90^{\circ}$ ) and minor axes. The condensation noticed in the B-band along the major axis has average brightness of  $20.22 \text{ mag. arcsec}^{-2}$  with relatively blue color  $B-V=0.09$ .

### 3.2. Luminosity Profiles

The B and V luminosity profiles along major and minor axes have the major axis taken at p.a. $\simeq 90^{\circ}$ . The luminosity profiles appear to possess a general smooth structure except for the complicated structure of the nuclear region and the presence of some humps in the outer region, especially along both sides of the major axis and the south side of the minor one. These outer humps occur at relatively high level, and we expect represent traces of unresolved spiral structure. The N-side (side of interaction) of the minor profile is clearly truncated at  $0.^{\prime}36$  due to the presence of the other component, NGC 7771.

### 3.3. Equivalent Luminosity Profiles, Integration and Decomposition

The B and V equivalent luminosity profiles are followed to  $\log I = -1.2$  at  $r = 0.^{\prime}69$  and up to  $\log I = -1.1$  at  $r = 0.^{\prime}36$  in the B and V bands respectively. The truncation of the northern side prevent us from reaching fainter levels. However, the profiles, within  $r = 0.^{\prime}36$ , are integrated and decomposed.

*Integration and total magnitude* The integrated B and V photographic magnitudes within  $r = 0.^{\prime}36$  are:  $m_T = 14.^m51$  and  $m_V = 14.^m05$  respectively, with the color index  $(B - V) = 0.^m46$ . The total B magnitude is  $m_{BT} = 14.^m25$  which is about  $0.^m15$  brighter than that reported in RC3, while the total color,  $(B - V)_T = 0.^m44$  is about  $0.^m15$  bluer.

*Profile Decomposition* The B and V luminosity profiles are decomposed into spheroidal bulge and flat disk components following Kormendy (1977). The decomposition parameters (effective intensity, effective radii, and luminosity of

the bulge and disk components) as well as bulge-to-disk ratio are obtained in the B and V bands and given numerically in Table 4.

The bulge-to-disk ratio is found to be 2.77 and 1.07 in the B and V bands respectively. The Freeman's parameters are:  $B_c=23.48\pm0.04$  mag.arcsec<sup>-2</sup> and  $\alpha=7.96\pm0.56$  kpc.

### 3.4. Color Distribution and Integrated Color

The integrated color along equivalent radius is found to be of abnormal distribution in comparison with normal spirals. The color index within the nuclear region ( $r=0'.16$ ) is:  $(B-V)_{\text{nuc}}=0.^m38$ , while that within  $r=0'.36$  is  $(B-V)=0.^m46$  i.e. the color of the nuclear region is bluer than that of the outer region. The blue color of the nuclear region relative to that of the outer region, and the blue total color index  $(B-V)_T=0.^m44$  together with the color index  $(U-B)=0.^m13$  (Tamazyan 1984) are relevant properties of the UV-excess galaxies. Hence these results confirm the classification of this galaxy as UV-excess one. The blue color of the outer region of this galaxy probably confirms the presence of spiral structure mentioned by Egiazaryan (1983).

### 3.5. Position Angle and Ellipticity Curves

The isophotal parameters of the best fit ellipses are calculated. The curves show clearly that this galaxy has two main parts of different behavior, the inner part represents the main body and the outer part represents the outer envelope in which the main body is embedded. The outer part is clearly affected by the presence of the other component NGC 7771. The position angle within  $a=0'.182$  is found to be  $62.^{\circ}72\pm5.^{\circ}01$ , while that of the outer envelope for  $a > 0'.23$  is  $-7.^{\circ}12\pm4.^{\circ}79$  which means that the outer envelope is oriented more or less perpendicular to the main body of the galaxy. This could be explained as the outer envelope is subject to a strong twist due to the presence of the other component. The ellipticity increases from 0.54 for the 2nd isophote until it reaches a maximum value of 0.96 for the 7th isophote; then it decreases in the outer three isophotes.

## 4. Discussion and Conclusion

The state of interaction between the components of the pair is confirmed by the presence of the peculiar features noticed in the distortion of the isophotes and in the unusual appearance of the structural profiles (ellipticity and position angle profiles). A lower limit of the total orbital mass of the system is  $1.36 \times 10^{10} M_{\odot}$ , with total mass-to-luminosity ratios  $f=0.63 f_{\odot}$ . The complex structure of the nuclear region of the small component NGC 7770 is confirmed in the B-band, while the V-band shows double nuclear structure. A faint disk component is recognized from the decomposition of the equivalent luminosity profile.

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