MULTICOLOUR SURFACE PHOTOMETRY OF SEYFERT GALAXIES: FIRST RESULTS

Luba S. Slavcheva-Mihova, Georgy T. Petrov, Boyko M. Mihov

Institute of Astronomy, Bulgarian Academy of Sciences,

Introduction

One- or two-dimensional decomposition of surface brightness distribution to its individual components is a technique widely used in studying Seyfert galaxies. Almost all decompositions of Seyfert galaxies light distribution made by different groups are based on the following analytical models for the separate components: single/double Gaussian for the nucleus, de Vaucouleurs law for the bulge and exponential law for the disk (e.g. [1], [2]). However, firstly, it was found that Sersic law is more suitable to model the bulge light distribution ([3]) and, secondly, important components of spiral galaxies light distribution are missed in the decompositions of Seyferts, namely, the bar and the lens ([4]). Using de Vaucouleurs law instead of Sersic one and neglecting the bar and the lens light distributions simplifies the numerical computations but could lead to systematic errors in the model parameters and in the total magnitudes.

In this paper we make an attempt to account for the above two problems. For this purpose we obtained *UBVR*c*I*c broad-band images of a number of galaxies have already been decomposed by other authors. In addition we observed several galaxies for which no surface brightness distribution decomposition had been done before.

Observations

Observations were performed with the 2-m Ritchey-Chretien telescope of the Rozhen National Astronomical Observatory of Bulgaria equipped with 1024x1024 Photometrics CCD camera (CCD chip SITe SI003AB with 24μm pixel size that corresponds to 0.309 arcseconds on the sky) and standard Johnson-Cousins filters. Observations were carried out from June 1, 1997 till April, 21, 1999 for a total of 22 nights. A total of 33 galaxies were observed; 21 of them were imaged once, the other 12 - between 2 and 4 times at different epochs. The CCD camera was used in both full and 2x2 binned mode upon the seeing conditions. Standard fields in the clusters M67, M92 and NGC7790 were observed 2 or 3 times per night. Flat field frames were taken in morning and/or evening twilight. Zero exposure frames were taken regularly during each observing run. The dark current is negligible as the CCD camera is cooled down to –100 degrees of Celsius. *I*c band frames of relatively blank night sky regions were taken for the fringe frame composition by dithering the telescope between the exposures to prevent eventual stars from landing on the same location. We found the fringe pattern did not change for the entire period of observation.

Data reduction

The primary reduction of the data was performed by means of ESO-MIDAS package. The debiased frames were flat fielded and cosmic ray events cleaned. We created a super fringe frame for the whole set of observations, with the help of which the *I*c band images were defringed. All frames of an object were shifted to match the *R*c frame and then coadded to create the final frame.

Extraction of one-dimensional galaxy profiles was performed with ESO-MIDAS context SURFPHOT. The frames were adaptive filtered, the background stars were removed from the galaxy image and the sky background was subtracted before the ellipse fitting. The sky background was determined by fitting a tilted plane to regions of the frame free of objects or CCD chip defects. The ellipse fitting itself was performed following the algorithm presented in [5]. As a result of the ellipse fitting radial profiles of surface brightness, ellipticity and position angle were obtained for each galaxy image in each band. We also computed the fourth order cosine Fourier coefficient profile examining the two-dimensional difference between the image and the corresponding ellipse model (e.g. [5]). Finally, the surface brightness profiles were transformed to the standard Johnson-Cousins photometric system using standard stars in the fields of M67 ([6]), M 92 ([7]) and NGC 7790 ([8]) clusters.

Results

Sample *UBVR*c*I*c profiles of the surface brightness, colour index, ellipticity, position angle and fourth cosine Fourier coefficient versus the major semi-axis for the galaxy Mrk79 observed on February 16, 1999 (seeing was about 3 arcsec) are presented in Fig. 1.

The galaxy Mrk79 is a barred spiral and from its profiles some useful information could be extracted: bar length of about 20 arcsec; host galaxy *B–V* colour of about 0.8-0.9 mag; bar ellipticity and position angle of about 0.55-0.6 and 51 deg, respectively; disk ellipticity and position angle of about 0.15-0.2 and 150 deg, respectively. The fourth cosine Fourier coefficient is close to zero, so the galaxy isophotes are well represented by ellipses. The run of the ellipticity, position angle and fourth cosine Fourier coefficient profiles is similar in the different bands; the structures in the inner 6 arcsec (or two seeing disks) are not real because of seeing and sampling influence.

We also made two kinds of profile comparisons in order to check the accuracy of our results. Firstly, we compared surface brightness profiles of galaxies observed twice or more in different epochs. The result of such a comparison is presented in Fig. 2 in the case of the galaxy NGC4151 observed on March 10, 1999 (solid line) and on April 19, 1999 (a dashed line). Secondly, our profiles are compared with the ones presented in [9]. In Fig. 2 and in Fig. 3 we present the results of such a comparison in the cases of NGC4151 and Mrk766 (observed on February 15, 1999) galaxies, respectively. In both figures only *V* band profiles are presented.

One can see the good correspondence between our profiles at different epochs and between our profiles and the profiles presented in [9]. The differences in the central part are due to the nuclei variability and the differences in the outer part are due to the sky background determination errors (over- or under- subtraction of the sky level). The region of NGC4151 profile between 40 and 80 arcsec is dominated by spiral arms which have irregular structure: this could lead the ellipse fitting algorithm to find slightly different solutions in this region depending on the seeing, signal to noise ratio and background determination. This could explain the profiles' difference in this region observed in Fig. 2.

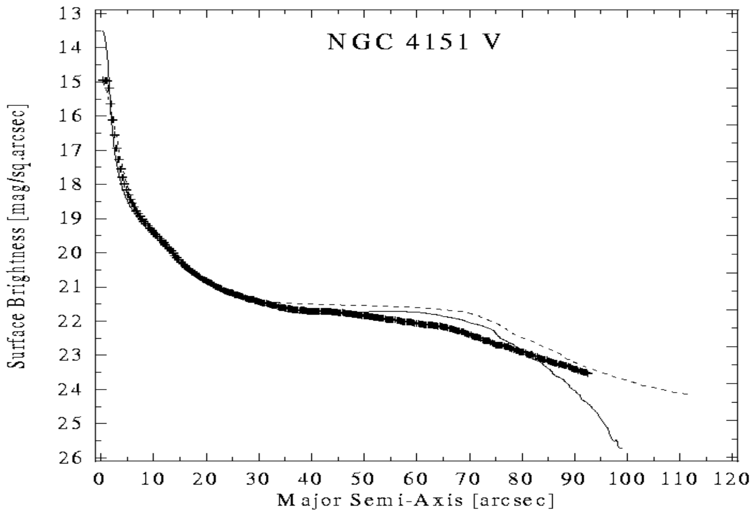

Fig. 2. *V* band profiles comparison in the case of NGC4151 galaxy: a solid line – March 10, 1999 profile, a dashed line – April 19, 1999 profile and crosses – the profile presented by [9].

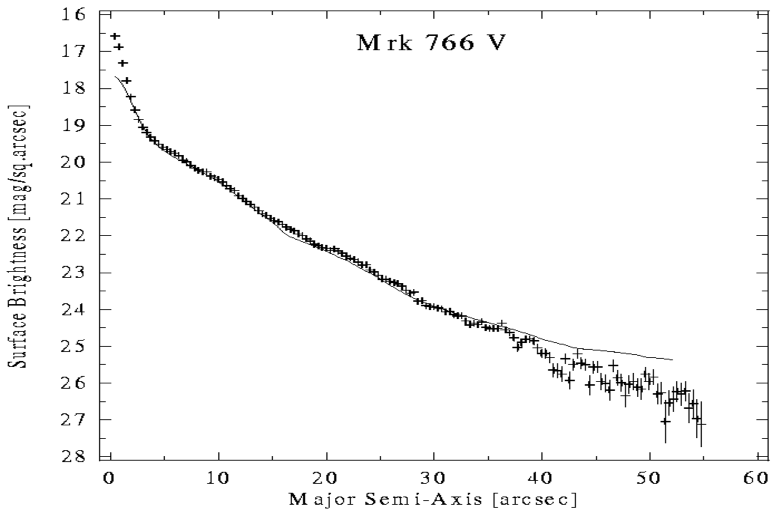

Fig. 3. *V* band profiles comparison in the case of Mrk766 galaxy: a solid line – February 15, 1999 profile and crosses – the profile presented by [9].

|

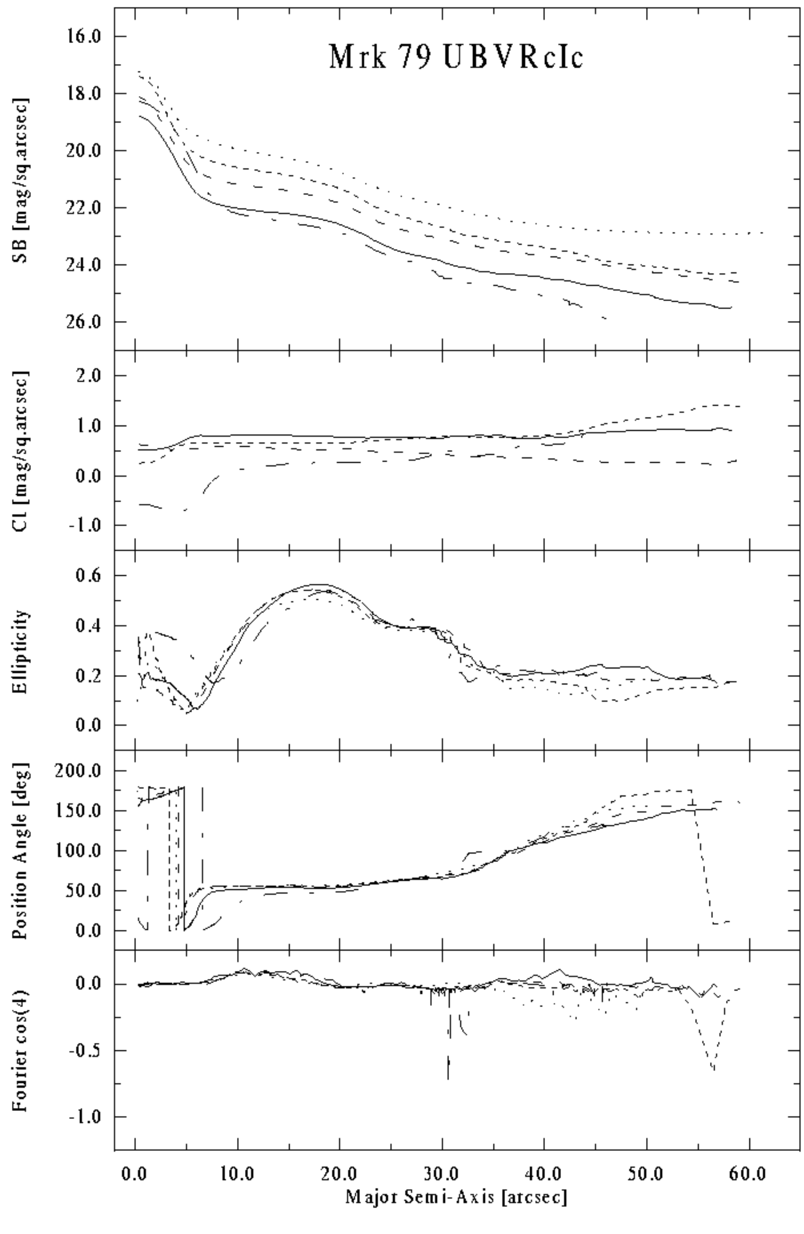

Fig. 1. Profiles of surface brightness, colour index, ellipticity, position angle and fourth cosine Fourier coefficient versus the major semi-axis for the galaxy Mrk79. *U* and *U*–*B* profiles are represented by a dash-dotted line, *B* and *B*–*V* – a solid line, *V* and *V*–*R*c – a long dashed line, *R*c and *R*c–*I*c – a short dashed line and *I*c – a dotted line.

References

1. G r a n a t o G. L., V. Z i t e l l i, F. B o n o l i, L. D a n e s e, C. B o n o l i, F. D e l p i n o. A study of a homogeneous sample of optically selected active galactic nuclei. III. Optical observations, ApJS, 89, 1993, 35-56

2. V i r a n i S. N., M. M. D e R o b e r t i s, M. L. V a n D a l f s e n. A CCD Study of the Environment of Seyfert Galaxies. III. Host Galaxies and the Nearby Environments, AJ, 120, 2000, 1739-1749

3. A n d r e d a k i s Y. C., R. H. S a n d e r s. Exponential bulges in late-type spirals: an improved description of the light distribution, MNRAS, 267, 1994, 283-296

4. K o r m e n d y J. Brightness distributions in compact and normal galaxies. I - Surface photometry of red compact galaxies, ApJ, 214, 1977, 359-382

5. B e n d e r R., C. M o e l l e n h o f f. Morphological analysis of massive early-type galaxies in the Virgo cluster, A&A, 177, 1987, 71-83

6. C h e v a l i e r C., S. A. I l o v a i s k y. Cousins BVRI CCD photometry of stars in the M67 "dipper asterism", A&AS, 90, 1991, 225-229

7. M a j e w s k i S. R., R. G. K r o n, D. C. K o o, M. A. B e r s h a d y. Deep UBVRI photometric calibration of high-latitude fields: SA 57 (1307+30) and Hercules (1720+50), PASP, 104, 1994, 1258-1270

8. P e t r o v G., W. S e g g e w i s s, A. D i e b a l l, B. K o v a c h e v. CCD standards for U and I in the open cluster NGC 7790, A&A, 376, 2001, 745-750

9. H u n t L. K., M. A. M a l k a n, B. R u s h, M. D. B i c a y, B. O. N e l s o n, R. M. S t a n g a, W. W e b b. Morphology of the 12 Micron Seyfert Galaxies. II. Optical and Near-Infrared Image Atlas, ApJS, 125, 1999, 349-362