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Optical and near-IR imaging of dusty ellipticals

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Abstract. In this paper we present some of the results of imaging observations of dusty ellipticals in the optical B & R bands as well as in near IR K′-band taken at the Las Campanas Observatory, Chile. We derive radial profiles of surface brightness, position angle, ellipticity as well as profiles of higher order Fourier coefficients by fitting ellipses to isophotes for each band. As the effect of dust obscuration is very much reduced in the near-IR, a comparison of isophotal profiles in the K′-band with those of optical bands permits us to analyze the effects of dust extinction in the dusty ellipticals. We examine optical & optical-IR color maps, color profiles, color gradients and discuss the results.

1. Introduction

At near-infrared (NIR) wavelengths the effect of dust obscuration is less severe than at optical wavelengths and hence imaging in NIR, specially in the K-band, can reveal new features unseen at optical bands. NIR and optical-NIR colors and their gradients have proved very useful in deriving information about the stellar populations in galaxies (Peletier et al. 1990a, Tendrup et al. 1995). NIR imaging has also been used in studying the morphology of dusty galaxies (Rauscher 1995) as well as in determining scale lengths of the bulge and the disk (Peletier & Balcells 1997). We have carried out a detailed surface photometric analysis of some dusty ellipticals in optical B & R as well as in NIR K′-band (a variant of the standard K-band) with the objective of studying morphological structure and to derive (B-R) & (B-K′) colors and their gradients for these galaxies.

2. Observations and data reduction

Observations of five dusty ellipticals (NGC1199, NGC6758, NGC6776, NGC6868, and NGC6958) were carried out in optical B and R bands as well as in the NIR K′ band. For optical observations the 1m Swope telescope of Las Campanas Observatory, Chile equipped with 800 x 800 TEK CCD was used, while for NIR K′-band observations both the 1.0 m. Swope

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and 2.5 m Du Pont telescopes at Las Campanas Observatory, Chile, and 256 x 256 HgCdTe, NICMOS-3 near-IR camera were used. Basic properties of the program galaxies are summarized in the Table 1.

Table 1. Basic properties of galaxies

Galaxy	Classification	v_{grp} km/s	$B_T{}^0$ [mag]	M_B [mag]	F_{100} [mJy.]
NGC1199	E3	2331	12.22	-21.12	<80
NGC6758	E2	3376	12.29	-21.86	310 ± 102
NGC6776	E+	5480	12.75	-22.45	580 ± 149
NGC6868	E3	2858	11.42	-22.37	1470 ± 96
NGC6958	E	2627	12.17	-21.43	2020 ± 53

Notes to Table 1. Columns (2) lists the galaxy classification taken from the RC3 (de Vaucouleurs et al. 1991), column (3) lists the radial velocity, column (4) lists the total blue magnitude, column (5) lists the absolute blue magnitude for assumed distances (H_0 = 50 km sec^{-1} Mpc^{-1}), column (6) lists the 100μm flux density.

Preliminary data reduction for optical images was carried out using the standard tasks available within IRAF to obtain clean sky substracted images of the galaxies I.

For NIR images preliminary reduction was done using the package nic3-scripts developed by group of Astronomers in Las Campanas Observatory, Chile. This software works within IRAF.

3. Analysis and results

- **Isophotal shape analysis :** Ellipses were fitted to the isophotes of the galaxy images using *ellipse* task available in STSDAS, based on the method devised by Jedrzejewski (1987). This gives surface brightness and profiles of geometrical parameters as well as coefficients of higher harmonics (a_3, b_3, a_4 and b_4). For the purpose of illustration profiles for NGC6868 are given in Figure 1. The general trend of the brightness and other geometrical profiles for these galaxies in NIR K′ band and optical B, R bands are similar, except for minor variations which can be attributed to the fact that effect of dust is very much reduced in the K′ band. Thus our results indicate that there is no significant difference in the morphological structures of the program galaxies in optical and NIR K′ bands.

- **Color-index map :** Color-index maps were generated using seeing corrected images in different filters. The (B-R) and (B-K′) color-index images for NGC6868 along with its B band image are shown in Figure 2. The color-index images in B-R as well as in B-K′ of this galaxy show nuclear dust in the form of a redder disk, having a spiral arm like feature extended only in one direction of the centre. This feature is more prominently seen in the optical-NIR (positive B-K′) color map of the galaxy, because of the broad base line in the wavelength for the B-K′ color and also due to the reason that dust extinction is very small in the K′-band.

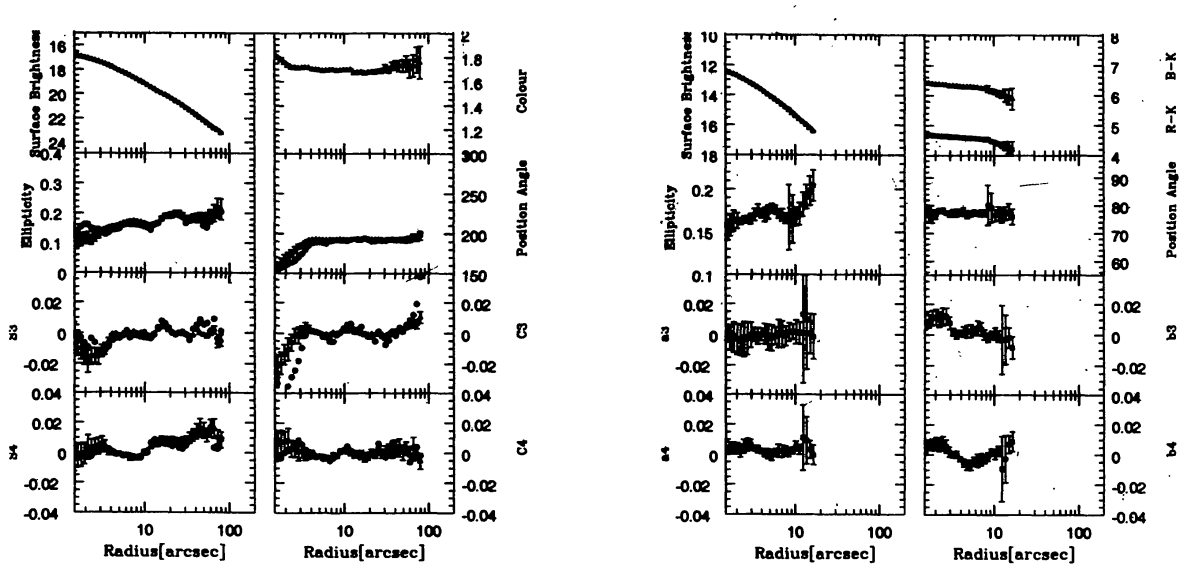

Figure 1. Results of isophotal shape analysis in optical B & R (left) and NIR K′-bands (right) for NGC6868.

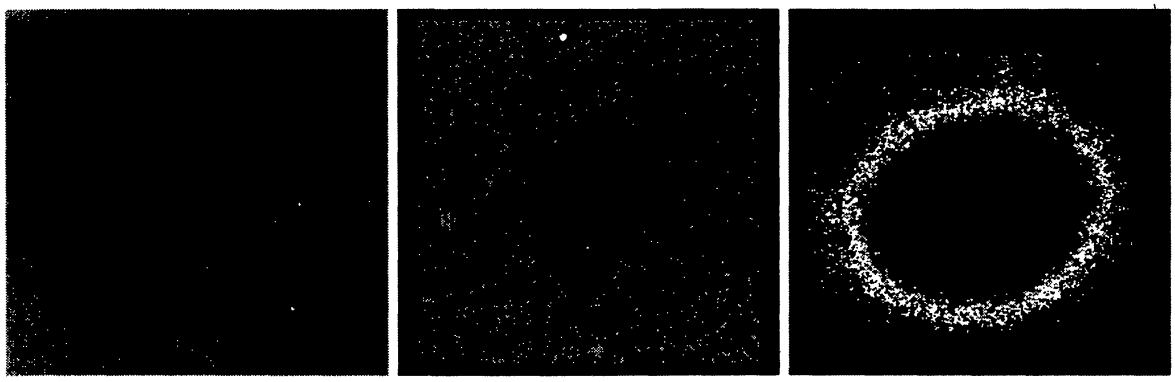

Figure 2. B band image (left), B-R band color image (center) and B-K′ band color image (right) of NGC6868.

- **Color gradient :** Colour gradients in (B-R) and (B-K′) were computed using the least square method of fit a linear relation in the logarithm of radius vs. color which gives color gradient in mag per dex in radius. These values along with their errors from the least square method are tabulated in the Table 2. The computed values of color gradients are also in good agreements with the published values of their gradient, wherever these are available.

Table 2. Color gradients.

Galaxy	$\Delta(B - K') / \Delta log(r)$	$\Delta(B - R) / \Delta log(r)$
NGC 1199	-0.13 ± 0.03	-0.04 ± 0.00
NGC 6758	-0.14 ± 0.01	-0.03 ± 0.00
NGC 6776	-0.34 ± 0.02	-0.11 ± 0.03
NGC 6868	-0.45 ± 0.01	-0.02 ± 0.00
NGC 6958	-0.78 ± 0.04	-0.15 ± 0.03

From Table 2 it is clear that the galaxies become bluer as one moves from central region to outer parts of the galaxy and in general galaxies having large gradients in (B-R) also have large gradients in B-K′. Similar results were obtained for a sample of bright ellipticals by Peletier (1990a, b). It indicates that the color gradients in different filters including those in NIR are closely related to each other, which in turn implies that these are caused by the same physical processes.

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