Formation and Evolution of Galaxy Disks
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Photometric Properties of Galactic Disks

A. S. Gusev,[1] O. V. Ezhkova,[1] A. P. Novikova,[1] E. V. Shimanovskaya,[1] and M. S. Khramtsova[2]

[1] *Sternberg Astronomical Institute, Moscow, Russia*
[2] *Ural State University, Ekaterinburg, Russia*

Abstract. We have analyzed the radial scales, central surface brightnesses, and colors of 403 disks of various types of galaxies. For 11 galaxies, the surface-brightness profile and central disk brightness were obtained via a two-dimensional decomposition of the $UBVRIJHK$ photometric images into bulge and disk components.

1. Introduction

Knowledge of the photometric parameters of disk components of galaxies is essential for studies of the dynamics and evolution of galaxies, dark matter, and the distribution of dust in galaxies. In the classical case of a thin exponential disk, it is described by two parameters in each photometric band: the disk scale length h and the central surface brightness μ_0. Various combinations of photometric parameters can be used to determine the radial color gradients (which depend on the age and chemical composition of the stellar population of the disk and the distribution of dust), and to estimate the distribution of the stellar mass and the central surface density of the disk.

Here, we use a sample of 403 galaxies with various morphological types and wide ranges of disk inclinations and galaxy luminosities to study the dependence of the photometric parameters of the disks on the morphological type of the galaxy, radial variations of the disk color indices, the influence of dust on the photometric parameters of the disks, and the dependence of the observed scale for the radial brightness decrease on the disk inclination. We also estimate the surface density and mass-to-luminosity ratio for a disk in the center of a galaxy.

For our study of the photometric parameters of disks we used the known data for 392 galaxies obtained earlier and also used our multi-color CCD photometry data for 11 galaxies: NGC 524, NGC 532, NGC 783, NGC 1138, NGC 1589, NGC 2336, NGC 4136, NGC 5351, NGC 6340, NGC 7280, and NGC 7351 in $UBVRIJHK$ (Gusev 2007).

For the sample of 11 galaxies we refined the model parameters of the bulge and disk (initially derived for the one-dimensional case) using the mask method to analyze two-dimensional galaxy images taken in various filters (Gusev 2006). The surface brightness of bulge and disk a were modeled with a Sérsic law and an exponential law, respectively.

2. Results

In the transition from early- to late-type galaxies, the central K surface brightness and the central surface density of the galactic disks decrease, the integrated and central color indices and central mass-to-luminosity ratio M/L_B decrease, and the relative size of the disk h/R_{25} and the ratio $h(\lambda_1)/h(\lambda_2)$ increase (here $\lambda_2 > \lambda_1$ are wavelengths of bands). The color gradient (normalizing by R_{25}) and the blue central surface brightness $\mu_0^{0,i}(B)$ are independent of the galaxy type. The disks in early-type galaxies appear to be denser at the center and shorter than the disks in late-type galaxies. The average age of stars in the disks in early-type galaxies is higher, and the linear gradients of the age and metallicity lower than those in late-type galaxies. The impact of dust on the photometric parameters of the disks and galaxies as a whole increases in the transition to late-type galaxies.

The disks in S0 galaxies have more homogeneous parameters than those in spiral galaxies. This may be due to the lower linear age and metallicity gradients of their stellar populations, as well as the lower amounts of dust in the disks of S0 galaxies. No sharp boundary in the properties of disks in lenticular, spiral, and irregular galaxies has been found all parameters vary smoothly along the Hubble sequence.

In all photometric bands, the central surface brightnesses of the disks increase with the total luminosity of the parent galaxy.

The ratio of linear disk scales measured in different photometric bands $h(\lambda_1)/h(\lambda_2)$ increases with the isophote ellipticity e of the disk (the inclination of the galaxy); however, the range of $h(\lambda_1)/h(\lambda_2)$ values for each e value exceeds the range of variations of $h(\lambda_1)/h(\lambda_2)$ over e. This is due to the fact that very broad intervals are observed for the radial variations of the composition of the stellar population in the disk and the parameters of the dust disks in the galaxies.

Dependence of $h(\lambda_1)/h(\lambda_2)$ on the average surface density of dust in a galaxy was found only for the galaxies with an uniform mixed dust in a disk:

$$h(B)/h(K) = (1.02 \pm 0.04) + (11.6 \pm 1.8) \times 10^{-5} \langle \sigma_{\rm dust} \rangle, \tag{1}$$

where the units for $\langle \sigma_{\rm dust} \rangle$ are $M_\odot$ kpc^{-2}.

Assuming that the surface density distribution in the disk corresponds to the K-band surface brightness distribution, the dependence

$$h(K) = h(\sigma)/(1.07 + 0.02e) \tag{2}$$

can be used to determine the linear scale for the decrease of the surface density $h(\sigma)$ with an accuracy of $\pm 15\%$.

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References

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