Structural Parameters of Stellar Disks in Edge-on Galaxies from 2MASS Images

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ABSTRACT

We analyze the J, H, and Ks 2MASS images of 140 late-type edge-on galaxies selected from the RFGC catalog (which contains flat galaxies with major-to-minor axis ratio $a/b > 7$). The NIR scalelengths ($h$) and scaleheights ($z_0$) of the stellar disks are determined for all selected galaxies. The mean relative ratios of the scaleheights of their stellar disks are 1.00:0.91:0.86 in J:H:Ks bands, respectively. We infer that the scaleheight determined from the Ks-band images is, on average, 13\% larger than the extinction-free scaleheight. This difference is much larger if the scaleheights were found from the optical-band images. The relative thickness ($z_0/h$) of the stellar disks correlates well with their deprojected central surface brightness obtained from the 2MASS images. This project was partially supported by grant RFBR 04-02-16518.

1. Introduction, Data, and Analysis

Infrared observations are crucial for studies of the structure of edge-on galaxies. The all-sky 2MASS survey gives a good opportunity to enhance the number of edge-on galaxies available for studies in the near-infrared bands. Whereas faint parts of the galaxies are not seen in the 2MASS images, the thin disks of the galaxies are obtained with sufficient signal-to-noise ($S/N$).

We refer to the Revised Flat Galaxies Catalog (RFGC; it contains extragalactic objects with major-to-minor axis ratio $a/b > 7$) as to a source of edge-on galaxies. More than 200 RFGC galaxies with major axis size more than 1’ were selected. This size was estimated directly from the 2MASS images at the level $S/N \sim 3$ and is significantly less that commonly used diameter $D_{25}$. Of them, there are 140 galaxies taken in all three 2MASS bands: H, J, and Ks. We applied the technique described by Bizyaev & Mitronova (2002) to assess the structural parameters of edge-on disks: the radial ($h$) and vertical ($z_0$) scales, and central face-on surface brightness $S_0$. This method implies an analysis of photometric profiles drawn parallel to the major and minor axes of galaxy at a one-pixel interval. The $h$, $z_0$, and $S_0$ were obtained in the H, J, and Ks bands for selected 140 galaxies.

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2. Results and Discussion

The dust layer in spiral galaxies is thinner than the stellar disk (see Xilouris E. et al. 1999). Since dust extinction is more significant in the J, and less important in the $K_s$, we expect to obtain smaller scaleheights for the same galaxies in the $K_s$ and larger in the J. One of the program galaxy, RFGC 2946, is shown in Figure 1 in the J (top panel), H (middle), and $K_s$ (bottom) bands. In Figure 2 (upper panel) one can see the scaleheights in different 2MASS bands for all considered edge-on galaxies. The scales in all bands are normalized by the scaleheight in the J. Histograms in lower panel of Figure 2 show the same normalized scaleheights in the H (dotted line) and $K_s$ (dashed line). The mean relative ratios of the scaleheights are $1.00:0.91:0.86$ in J:H:$K_s$ bands, respectively.

The different values of scaleheights $z_0$ for different bands enabled us to infer the structural parameters of our edge-on galaxies under assumption of zero extinction, i.e. if they had no dust. Here we assume that the ratio of scaleheights is a linear function of the internal extinction coefficient in given photometric band. It can be shown that this approximation should work well for small optical depths, i.e. for the case of NIR photometry). Hence, one can figure out the extinction-free $z_0$ for the case of zero extinction coefficient. The resulting value of the extinction-free scaleheights is, on average, 0.76 in units of $z_0$(J). Hence, the $K_s$ scaleheight of thin stellar disks assessed in the $K_s$ band overestimates the original scaleheight by, on average, only 13 %. Because of the large extinction, the scaleheights in the optical photometric bands much more significantly overestimate the real vertical scales of the stellar disks.

As it was shown in Bizyaev (2000); Bizyaev & Mitronova (2002); Kregel et al. (2005), the stellar disks with dimmer central surface brightness ($S_0$) tend to have smaller ratios of scales ($z_0/h$). The dust extinction may ne responsible for at least a part of this relation. Now we can check the relation $z_0/h$ versus $S_0$ using the extinction-free scaleheights. The central surface brightness in the $K_s$ band is considered as $S_0$. Since the scalelength for our galaxies does not indicate a clear systematic variation between the J, H, and $K_s$ bands, we consider the $K_s$ scalelength here as the "h". Figure 3 suggests that correlation between the vertical to radial scales ratio ($z_0/h$) and disks’ $S_0$ is not due to dust, but has a physical reason.

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Fig. 1.— Edge-on galaxy RFGC 2946 in the J (top), H (middle), and K$_s$ (bottom) bands.
Fig. 2.— Scale heights $z_0$ in 2MASS bands J, H, and $K_s$ for all considered edge-on galaxies (top). All scales in all bands are normalized by the scale heights in the J. Histograms in the bottom panel show the same normalized scale heights in the H (dotted line), $K_s$ (dashed line), and extinction-free (solid).
Fig. 3.— Relation between the vertical to radial scales ratio ($z_0/h$) and the deprojected disks’ central surface brightness $S_0$. 