Edge-on Disk Galaxies in the Near-Infrared

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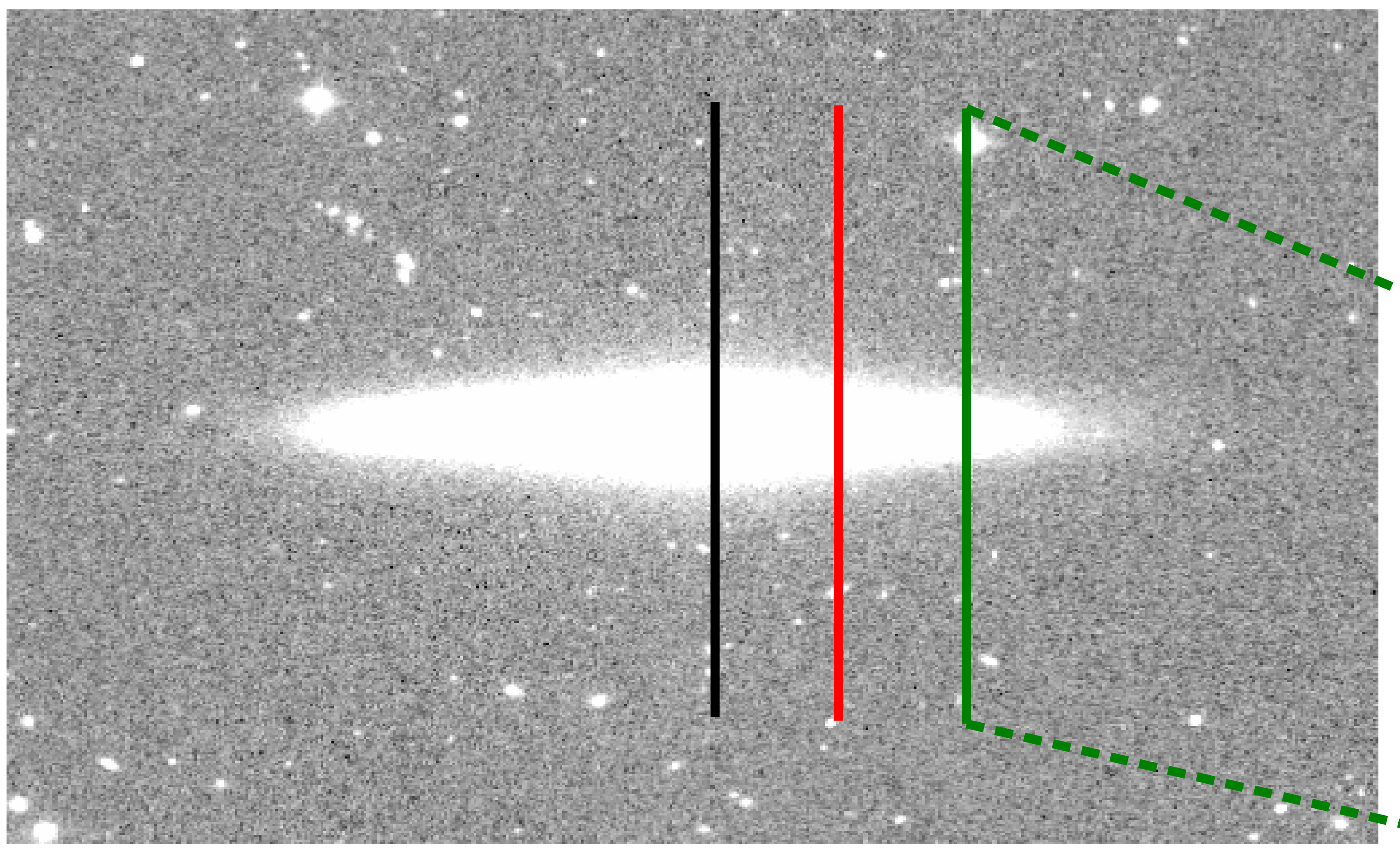

Figure 1: Reduced and rotated image of the Sbc galaxy NGC 5290 with a total size of 320″×240″. The three lines are vertical cuts along the minor axis of the galaxy at different radial positions along the major axis; respectively at 0″, 30″ and 60″ from the center. The resulting profiles are plotted in Figure 2.

NGC 5290 Properties

Type	Sbc: sp
T[a]	3.7 (RC3)
RA (2000)	13 45 19.2
DEC (2000)	+41 42 45
Diam. (′)	3.09
v_{vir} (km s^{-1})	2817
D (Mpc)	39.7
v_{rot} (km s^{-1})	220.9
M_B^0 (mag)	-20.66

[a] Hubble Type coding

Abstract

The aim of this research is to study the radial and vertical distribution of stars in late type disk galaxies using surface photometry, focusing on thick disks. Thick disks are a faint and extended stellar component, containing the oldest disk stars, so they are likely to trace the early stages of galaxy formation and evolution.

To do this about 10 edge-on disk galaxies were observed in the *J*-and/or *K*′-band with the 3.5-m Calar Alto or the 4-m UKIRT telescope. We use near-infrared images because those are much less contaminated by the absorbing dust in the mid-plane when doing structure analysis. We have developed an IRAF package used for data reduction to obtain images with extremely flat and low noise backgrounds. We show here colour and surface brightness profiles as cuts parallel to the minor axis of the disk, searching for a thick disk component.

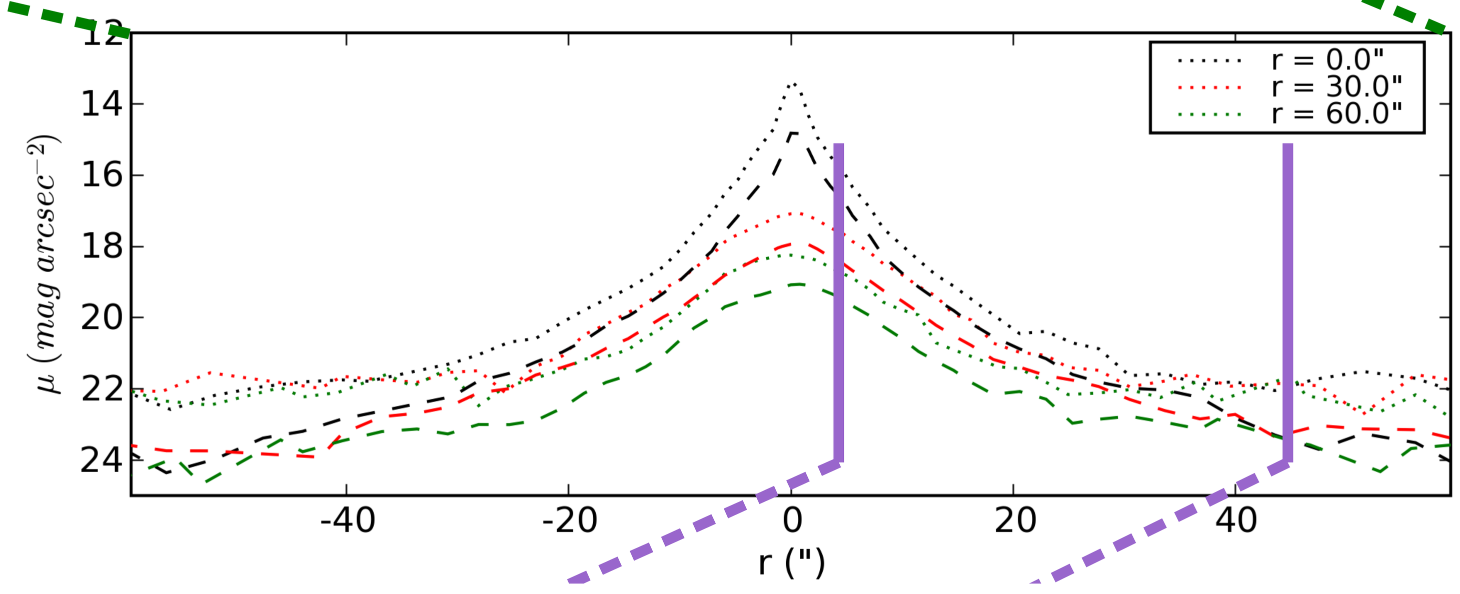

Figure 2: Example of vertical surface brightness profiles at three radial positions along the major axis. The dotted lines are the distributions in the *K*′-band, the dashed lines the distributions in the *J*-band. The vertical cutlines correspond to the region to which the fits were made.

The Thin and the Thick Disk

History

Originally a disk galaxy had three distinct components: a disk population, a bulge component, and a stellar halo. In 1979 Burstein and Tsikoudi revealed with deep surface photometry the need for an additional component of stars, the "thick disk". In the following years this quickly gained support, especially since our own galaxy contained stellar populations matching Bursteins definition of the thick disk; the name originating from a disk-like distribution with larger scaleheight compared to the inner, dominating "thin disk".

Research

Since that time thick disks have been found to be common components in lenticular and early type disk galaxies, but for late type galaxies it has not been considered a common feature. Over the years observational techniques are allowing us to observe further out of a galaxy than before. This research attempts to discover distinct thick disk components in late type disk galaxies using deep surface photometry. We follow the footsteps of previous research by De Grijs et al. (1997) and Yoachim and Dalcanton (2006) to obtain our goal, while using our own methods.

Binned Profiles

To find the different disk components first vertical surface brightness profiles have to be made of the galaxy at different radial positions along the major axis (see Figures 1 and 2 for an example). The profiles are binned, exponentially growing from the center so that in the outer parts more area contributes to the mean intensity to gain a higher S/N ratio.

Subtracting the *J*- and *K*′-band profiles gives a colour profile of the galaxy (see Figure 3). The center left peak of the profile shows where the dust lane lies. The light in the *K*′-band image is absorbed much less by the dust than the *J*-band image.

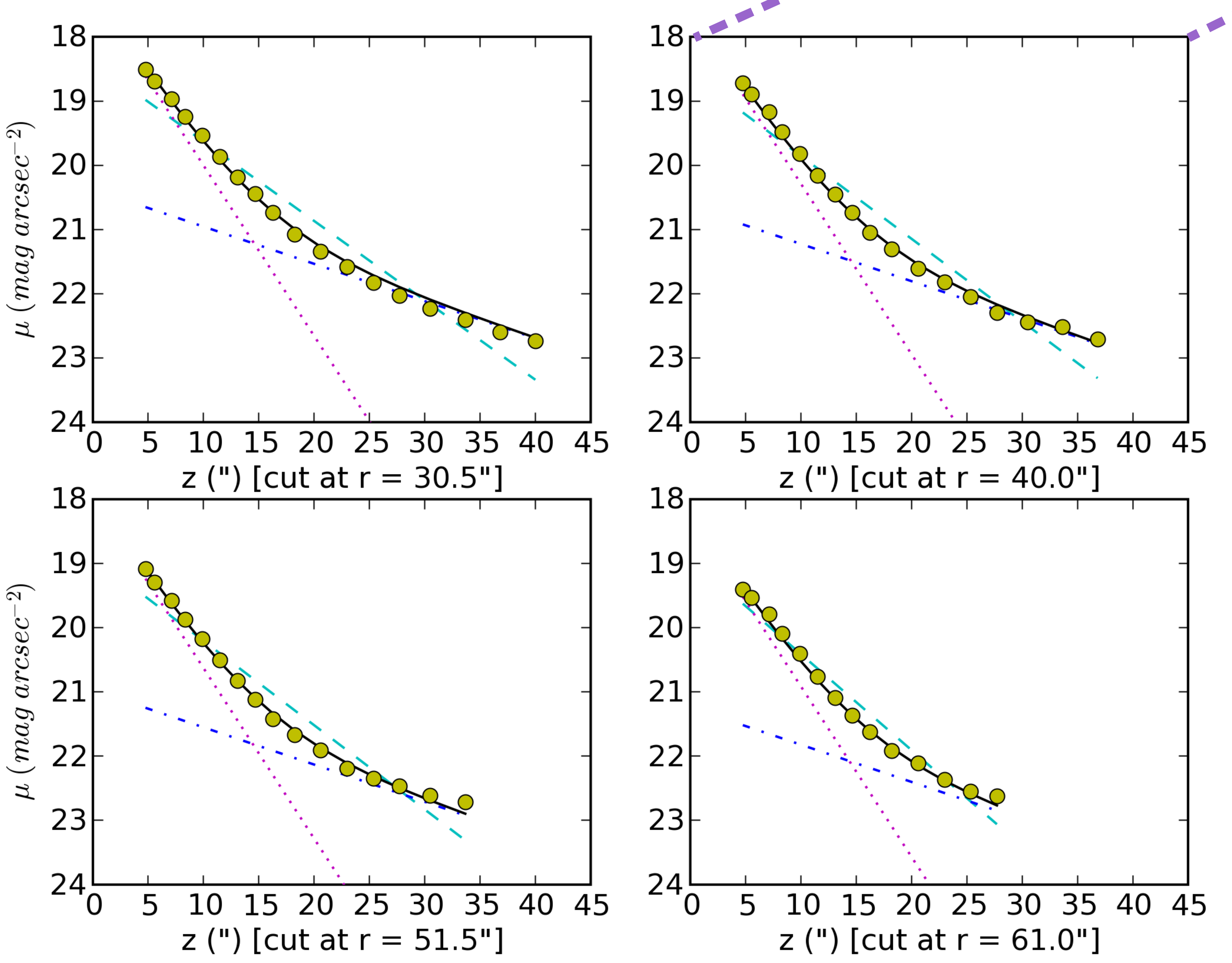

Figure 4: Fits to the vertical surface brightness profiles of NGC 5290 in the *J*-band shown at 4 different radial positions. The big dots are the data points from the image, the straight is line the fit, the dotted line the thin disk contribution, the dashed-and-dotted line the thick disk contribution and the dashed line a single exponential fit for comparison.

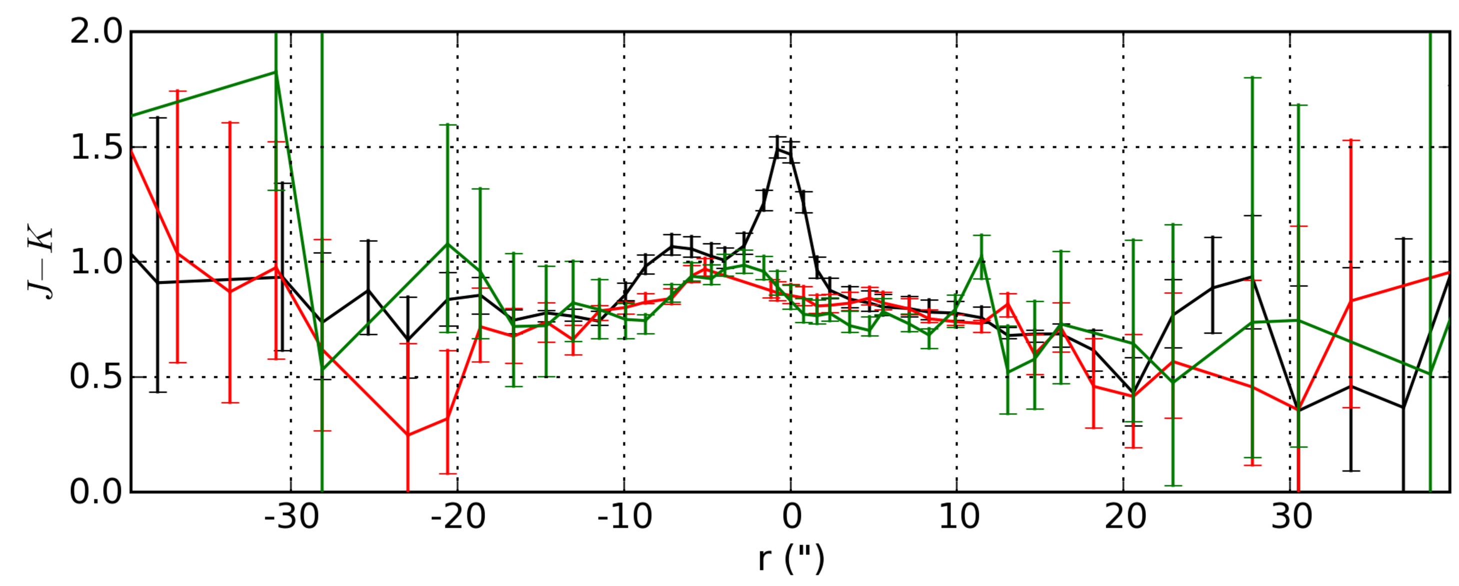

Figure 3: *J*-*K*′-band vertical surface brightness colour profiles at three radial positions along the major axis, made with the profiles from Figure 2.

2D Two-Disk Profile Fits

Figure 4 shows the first 2D two-disk fit on the *J*-band image of NGC 5290 we made at different radial positions, giving a distinct thick disk component and a profile that cannot be fitted with a single disk.

NGC 5290 is a similar Sbc galaxy like our own Milky Way, so we can compare the results.

	Band	z_0 (pc)	z_0 (″)	f_z	h_0 (kpc)	h_0 (″)	f_h
NGC 5290	*J*	770	4.0	4.5	6.9	36.0	1.0
NGC 5290	*K*′	770	4.0	4.5	6.6	34.0	1.2
Milky Way	NIR	260	-	3.3	2.8	-	1.3

The f_z ratio is high compared to literature values, but consistant for late-type galaxies. NGC 5290 is known to appear spindle-like, so an extended thick disk may be expected.

Fitting the Profiles

Data Selection and Two-Disk Fit

To further enhance our S/N ratio we cut the galaxy in four quadrants and averaged them. This way the profiles will be the same on all sides of the galaxy.

Not all parts of the galaxy are suitable for finding the thick disk. Using a horizontal profile over the major axis we determined the three radial components of the galaxy: the bulge, the inner disk and the outer disk. The inner disk has no contamination by the bulge or irregularities in the outer part of the disk. The radial surface brightness along the inner disk can be described by a simple exponential. All the vertical profiles within the inner disk were selected for our fit.

Datapoints within the background noise level were removed. In the inner part the vertical profile shows a downbending caused by seeing. We masked those datapoints that were influenced by the seeing because they are not important for thick disk fits and thus we don't have to take seeing effects into account for the fit. What remains should be described following:

$$\mu(r,z) = -2.5\log\left(I_0 e^{-r/h_0} e^{-z/z_0} + I_1 e^{-r/(f_h h_0)} e^{-z/(f_z z_0)}\right) + zeropoint$$

The left exponential part is the thin disk component, with its central surface brightness I_0, its radial scale length h_0, and its vertical scale height z_0. The right exponential part is the thick disk component, which contains additional ratios f_h and f_z to the scale length and the scale height of the thin disk. The fitting was done with the Nelder-Mead Downhill Simplex method, for the 6 free parameters.

References

Burstein, D., 1979, ApJS, 234, 829
De Grijs, R., Peletier, R.F., Van der Kruit, P.C., 1997, A&A, 327, 966
Pohlen, M., Balcells, M., Lütticke, R., Dettmar, R.-J., 2004, A&A, 422, 465
Tsikoudi, V., 1979, ApJ, 234, 842
Yoachim, P., Dalcanton J.J., 2006, AJ, 131, 226

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