The Bivariate Brightness Distribution of Galaxy Disks

Jochen Liske[1], Simon P. Driver[2] & Paul D. Allen[2]

www.eso.org/~jliske/mgc

[1]European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748, Germany
[2]RSAA, Australian National University, Cotter Rd, Weston ACT 2611, Australia

Read only the red bits for a succinct summary.

1. Introduction

The bivariate brightness distribution (BBD) quantifies the space density of galaxies as a joint function of luminosity and surface brightness and is hence an extension of the luminosity function. The BBD is linked to the mass and angular momentum distributions of galaxies and the different formation processes of different galaxy types or components are predicted to be encoded in their BBDs (e.g. Dalcanton et al. 1997; Mo et al. 1998; de Jong & Lacey 2000). Hence the BBD is a useful testbed for galaxy formation models.

Constructing the BBDs of disks and bulges separately is of particular interest in this respect. At z=0 this requires high-quality wide-field data with well-known selection limits.

2. Data: *The Millennium Galaxy Catalogue*

The Millennium Galaxy Catalogue (MGC; Liske et al. 2003, Driver et al. 2005) is a deep, wide-field B-band imaging survey conducted with the Wide Field Camera on the INT. The MGC covers 37.5 deg^{-2} to a limiting isophote of 26 mag arcsec^{-2} in the B-band and the catalogue contains ~370,000 galaxies in the range 13 < B < 24 mag. The MGC's purpose is to provide us with a detailed view of the local galaxy population for comparison with both high-z observations and models of galaxy evolution.

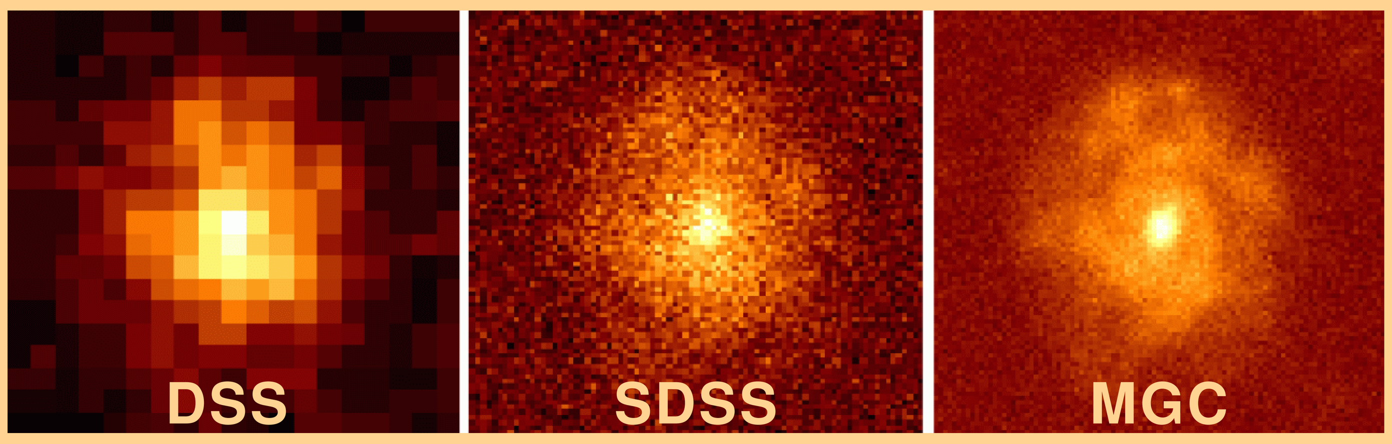

Fig. 1: We show three images of the same galaxy in this illustration of the MGC's excellent image quality. On the left we show a photographic image from the Digital Sky Survey (b_J-band), the middle image is from the Sloan Digital Sky Survey (g-band) and the right is the MGC B-band image.

Our main sample is defined as the 10,095 MGC galaxies with B < 20 mag. By mining public databases like the SDSS and 2dFGRS we found redshifts for 47% of this sample. We have supplemented these data with our own redshift survey, mainly using 2dF. To counter surface brightness bias in the redshift incompleteness (see Fig. 2) we also performed single-slit observations on Gemini, the NTT and the ANU 2.3m. The final redshift completeness is 96.05% and the median redshift of this sample is 0.12.

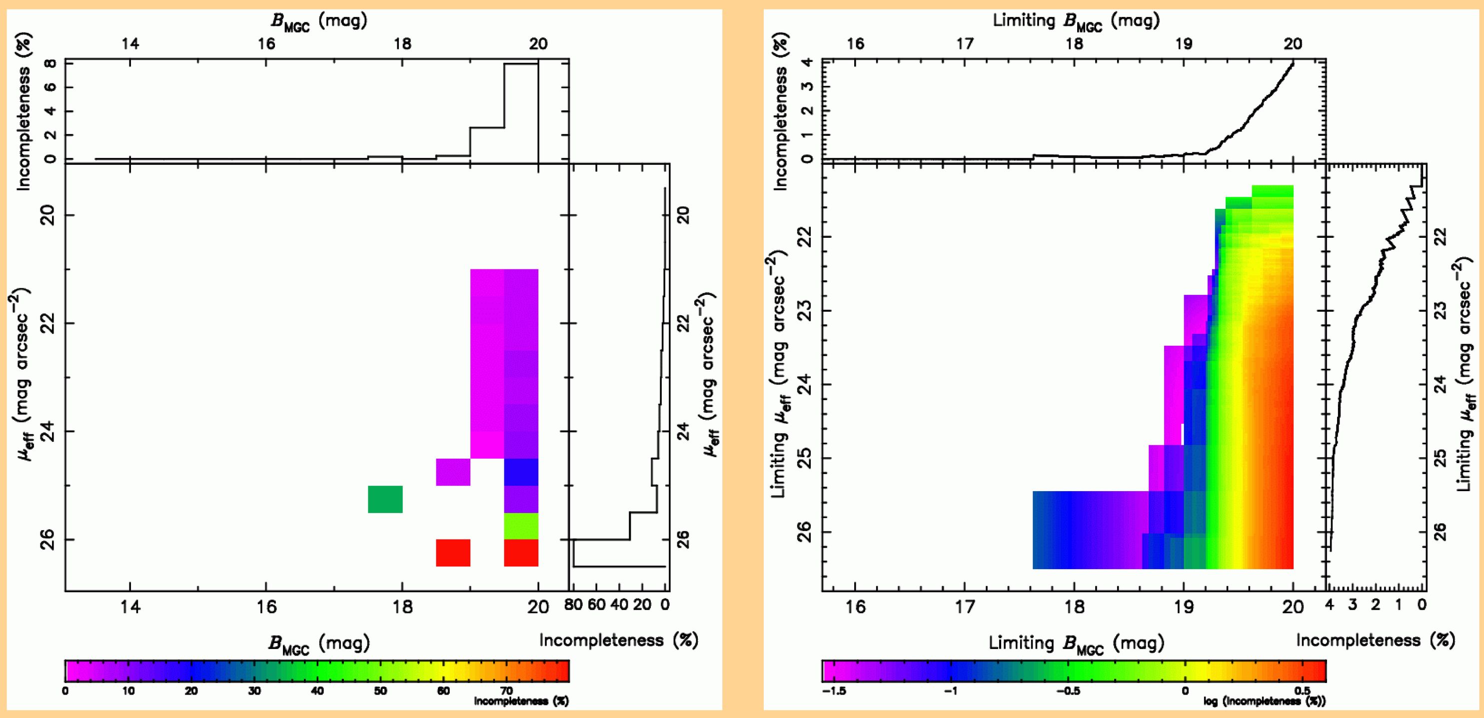

Fig. 2: The left panel panel shows the MGC's redshift incompleteness as a function of magnitude and surface brightness. Despite our single-slit observations some bias still remains. We account for this in the analysis. The right panel shows the incompleteness as a function of *limiting* magnitude and surface brightness. From the top sub-panel we can see that for B < 19.2 mag the incompleteness is only 0.21%!

3. Quantitative Morphology for 10,000 galaxies

The excellent MGC image quality enables us to decompose all galaxies with B < 20 mag into bulges and disks using GIM2D (Simard 1998). The MGC is currently one of the largest samples for which quantitative morphology is available. The 2D surface brightness profile is modelled as the sum of a Sersic bulge and an exponential disk, convolved with the seeing (see P. Allen's talk). Some examples are shown in Fig. 3. We have confirmed the reliability of this process using independent duplicate observations of ~700 objects in the overlap regions of neighbouring MGC fields.

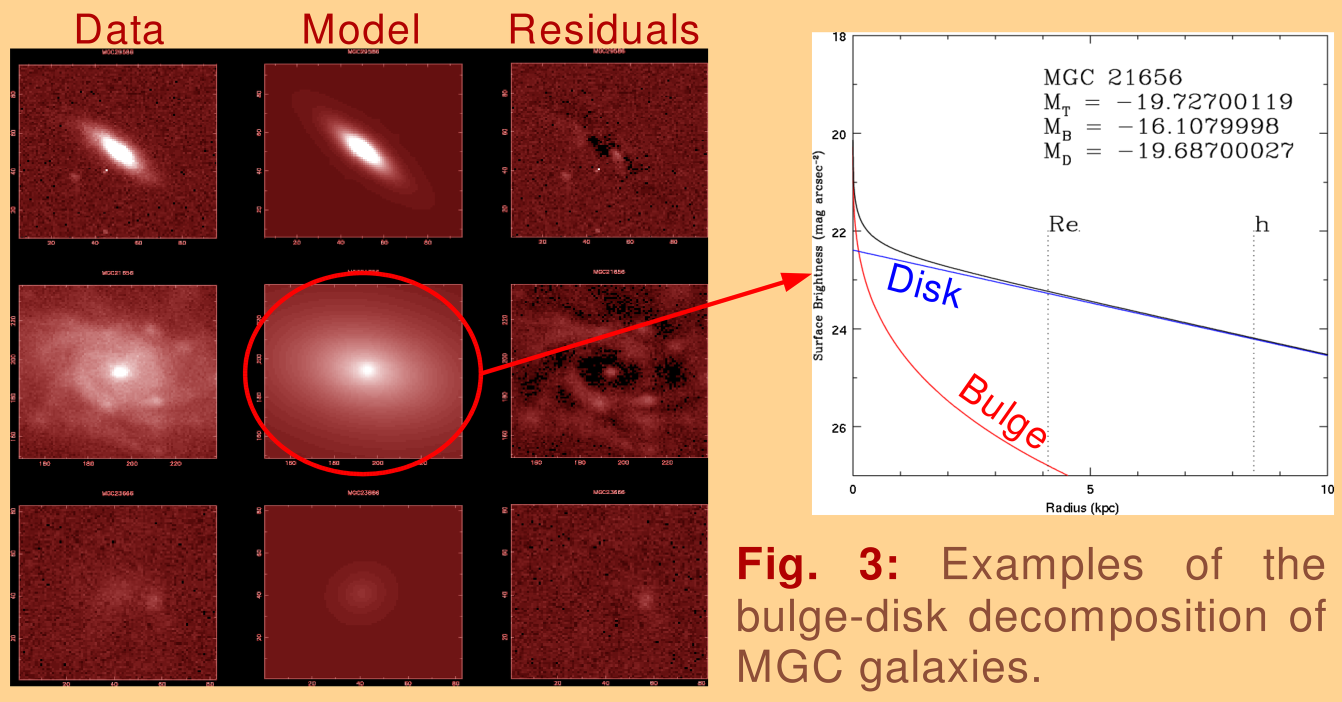

Fig. 3: Examples of the bulge-disk decomposition of MGC galaxies.

3. Preliminary Results: The BBD of Galaxy Disks

We use the bivariate step-wise maximum likelihood method of Driver et al. (2005) to construct the BBD of the disk components of galaxies. A full analysis of all relevant selection limits is still pending, but using very conservative selection limits yields a sample of 5721 disks with 0.013 < z < 0.18.

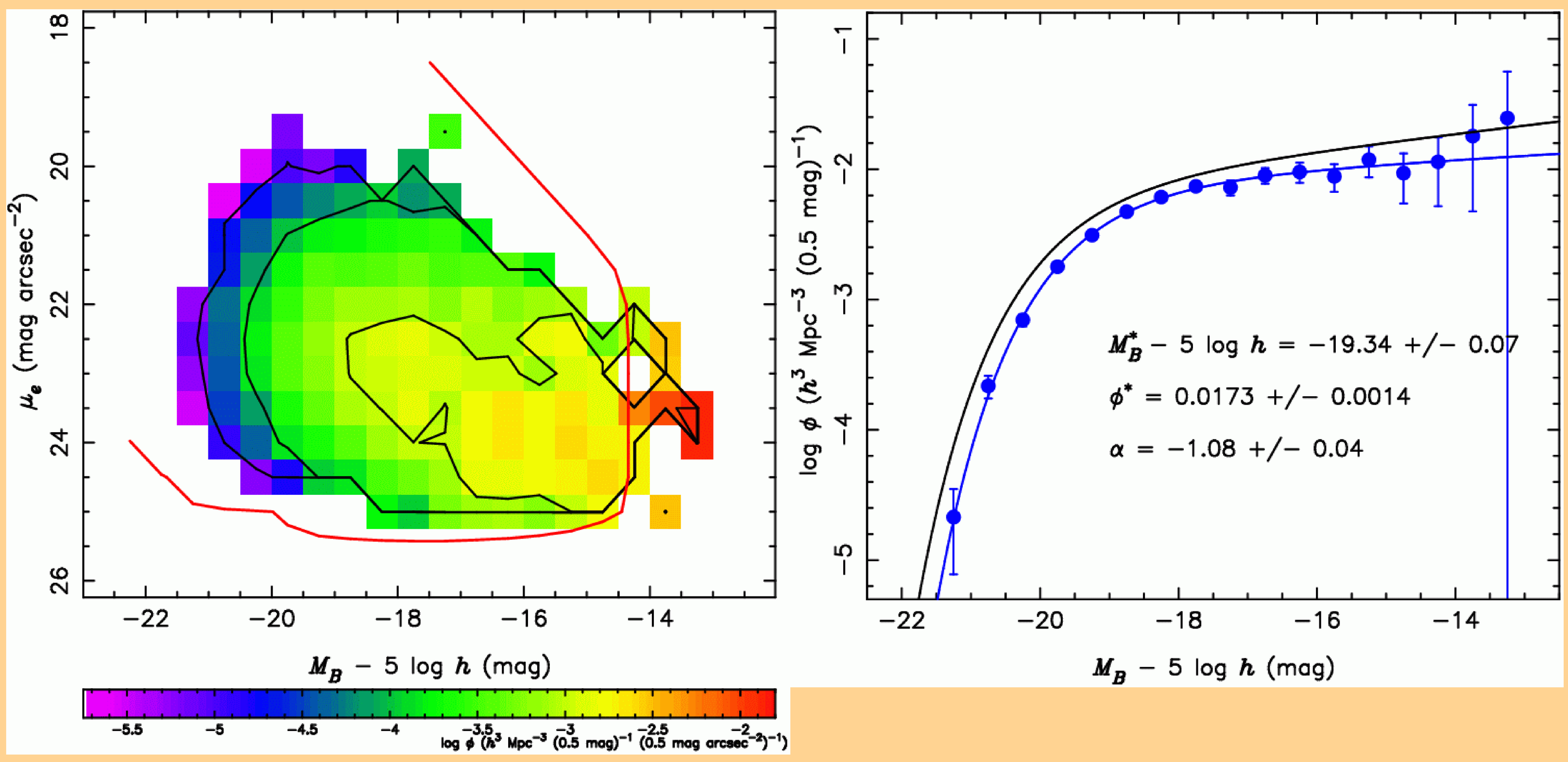

Fig. 4: The black contours and colour image in the left panel show the bivariate brightness distribution of galaxy disks. The red line encloses that part of parameter space which is probed by at least 100 objects and represents our selection limit. Integrating the BBD over surface brightness yields the disk luminosity function in blue in the right panel. The black line shows the total MGC luminosity function for comparison.

The BBD of disks exhibits a well-defined shape: at a given luminosity the distribution of surface brightness is Gaussian, i.e. the size distribution of disks is log-normal. The peak of the surface brightness distribution shifts to fainter values at lower luminosities. This surface brightness-luminosity relation is described by $\mu^* = 21.78 + 0.5(M_B + 20)$ mag arcsec^{-2}.

Clearly, the next step (Liske et al. 2005) is to perform a detailed comparison of these and other features of the disk BBD with the predictions of galaxy formation models.

References

Dalcanton J.J., Spergel D.N., Summers F.J., 1997, ApJ, 482, 659
de Jong R.S., Lacey C., 2000, ApJ, 545, 781
Driver S.P., Liske J., Cross N.J.G., De Propris R., Allen P.D., 2005, MNRAS, 360, 81
Liske J., Driver S.P., Allen P.D., 2005, MNRAS, in preparation
Liske J., Lemon D., Driver S.P., Cross N.J.G., Couch W.J., 2003, MNRAS, 344, 307
Mo H.J., Mao S., White S.D.M., 1998, MNRAS, 295, 319
Simard L., 1998, ASPC, 145, 108