THE BIVARIATE BRIGHTNESS DISTRIBUTION OF GALAXY DISKS

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Abstract Using the results of a bulge-disk decomposition of $10\,000$ galaxies with $B < 20$ mag from the Millennium Galaxy Catalogue, we recover the space-density of galaxy disks as a joint function of luminosity and effective surface brightness.

1. Introduction

The bivariate brightness distribution (BBD) quantifies the space density of galaxies as a joint function of luminosity and surface brightness (SB) 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 and Lacey, 2000). Hence the BBD is a useful test-bed for galaxy formation models. Constructing the BBDs of disks and bulges separately is of particular interest in this respect. However, at $z = 0$ this requires high-quality, wide-field imaging data with well known selection limits, and a corresponding redshift survey to high completeness.

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, covering 37.5 deg^2 in ~ 1.25 arcsec seeing to a limiting isophote of 26 mag arcsec^{-2}. The galaxy sample used here is defined as the $10\,095$ MGC galaxies that have $B < 20$ mag.

Public datasets (such as SDSS and 2dFGRS) together with our own redshift survey, mainly using 2dF, have yielded redshifts for 96.05% of this sample. This also includes a single-slit campaign on Gemini, the NTT and the ANU

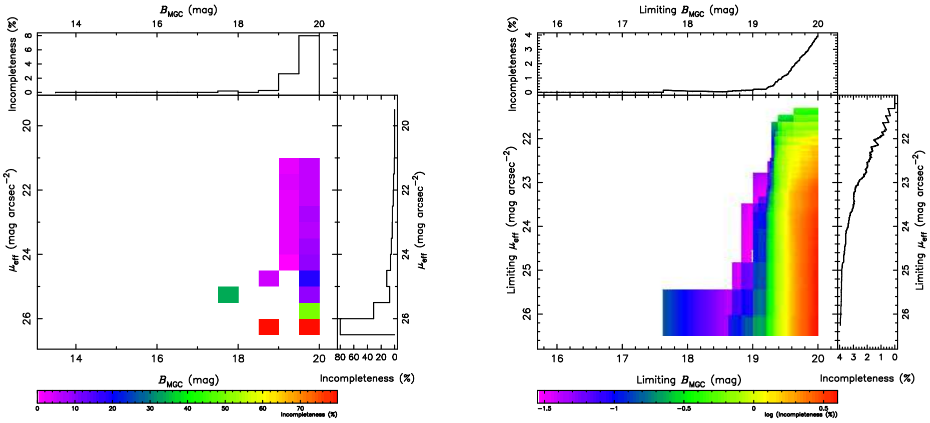

Figure 1. The MGC's overall redshift incompleteness is 96.05%. The left panel shows the incompleteness as a function of magnitude and surface brightness. Despite our single-slit observations some magnitude and SB-dependent bias still remains. We account for this in the analysis. The right panel shows the incompleteness as a function of *limiting* magnitude and SB. From the top sub-panel we can see that for $B < 19.2$ mag the incompleteness is only 0.21%.

2.3m in an attempt to mitigate the severity of the SB bias in the redshift completeness, which is inevitably introduced by using a fibre-fed MOS such as 2dF (see Fig. 1). The median redshift of our sample is 0.12.

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 contribution to these proceedings for details). We have confirmed the reliability of this process using independent duplicate observations of ~ 700 objects in the overlap regions of neighbouring MGC fields.

3. Preliminary results

We use the bivariate stepwise 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 here we conservatively set the low-SB and maximum size limits to the same values as in Driver et al.'s analysis of the total-galaxy BBD, i.e. $\mu_{\rm lim} = 25.25$ mag arcsec^{-2} and $r_{\rm max} = 15$ arcsec. These are not absolute detection limits but rather the limits to which accurate photometry is possible. The minimum size limit is determined by GIM2D's capability of recovering a component half-light radius, and we set it to 0.7 times the FWHM of the seeing. Within these limits we have a complete sample of 5721 disks with $0.013 < z < 0.18$.

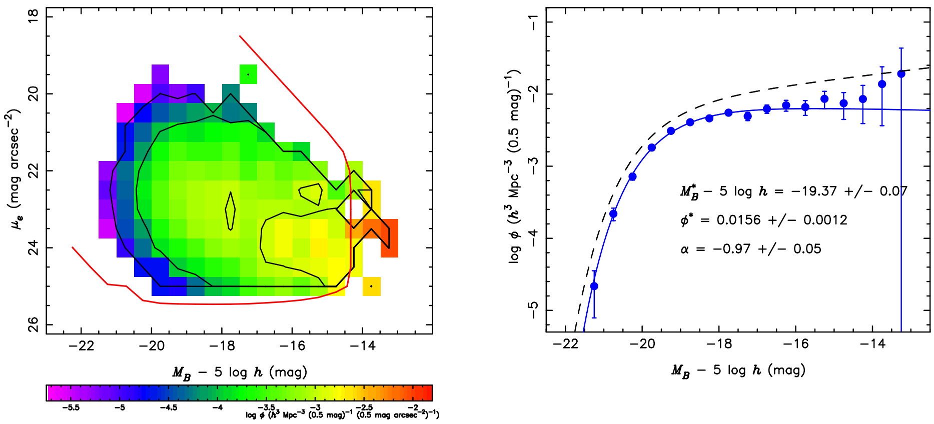

Figure 2. The contours and image in the left panel both show the bivariate brightness distribution of galaxy disks as derived from the MGC. The thick solid line encloses that part of parameter space which is probed by at least 100 objects and represents our selection limit. Integrating the BBD over surface brightness yields the disk luminosity function in blue in the right panel. The best-fit Schechter function parameters are indicated. The dashed line shows the total MGC luminosity function for comparison.

The resulting BBD of galaxy disks is shown in Fig. 2 (left panel). It 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 SB-luminosity relation is described by $\mu^* = 21.78 + 0.5(M_B + 20)$ mag arcsec^{-2}. Clearly, the next step is to perform a detailed comparison of these and other features of the disk BBD with the predictions of galaxy formation models.

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