GAMA: The Galaxy Mass-Size Relation

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INTRODUCTION

The Mass-Size Relation (MSR) is a key measurement highlighting that galaxies have experienced significant size evolution between z=2 and z=0 by a factor of up to 5 (e.g. Trujillo et al. 2007; see also Figure 1).
However, we do not yet fully understand how or indeed if galaxies have undergone the observed size growth.

Possible explanations include:

- Bad measurements at low and/or high redshift
- Eddington and other selection biases
- Software bias (i.e. dif. analysis technique at dif. z)
- Evolution of galaxies (Mergers, Relaxation, Disc Growth)

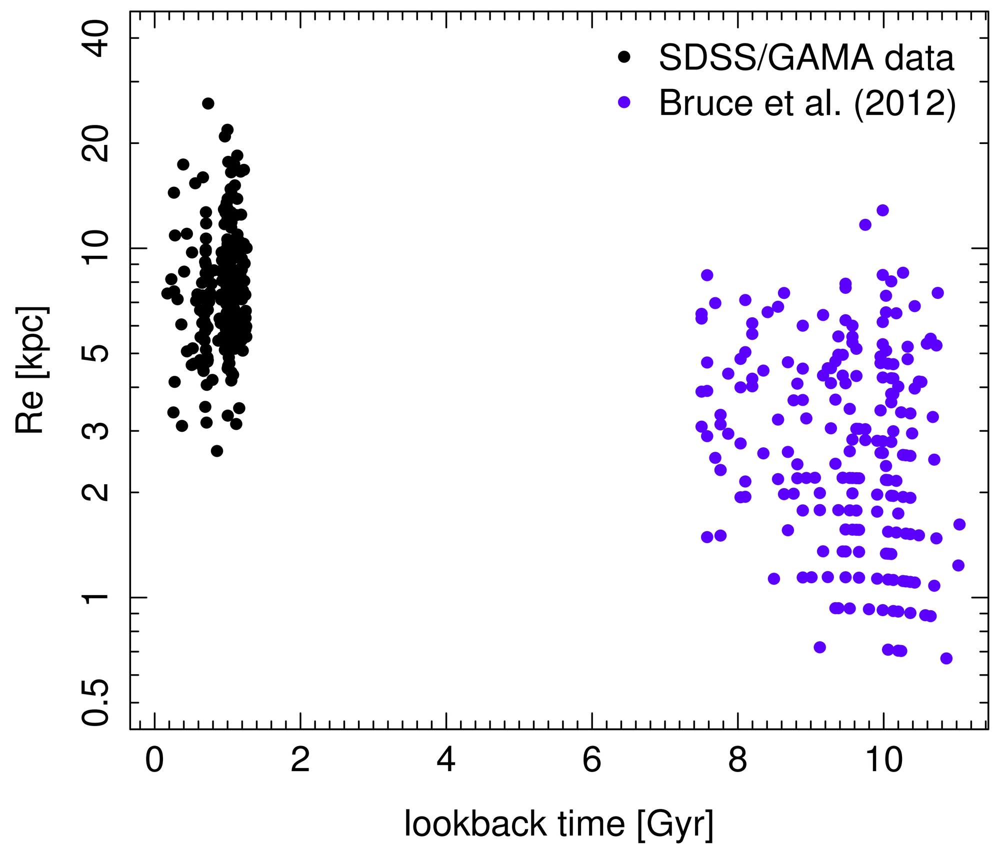


Figure 1: The observed half-light radius in kpc of massive galaxies ($M_*>10^{11}M_\odot$) for a sample of local (z=0) and high redshift (1<z<3) galaxies. On average the high mass galaxies are a factor of 3 smaller than their local counterparts.

Late type galaxies Case	a (10^{-3})	b	α	β	γ	M_0 (10^{10})
Fig. 3a (Sèrsic cut)	7.76	0.27	0.20	0.51	0.04	8.83
Fig. 3b (colour cut)	7.58	0.27	0.19	2.22	0.04	45.9
Fig. 3c (Sèrsic +colour)	8.51	0.27	0.19	2.95	0.05	58.9
Fig. 3d (morphology)	9.71	0.27	0.18	0.51	0.06	7.05
S03	-	-	0.14	0.39	0.1	3.98

Early type galaxies Case	a (10^{-5})	b	α	β	γ	M_0 10^{10}
Fig. 3a (Sèrsic cut)	631	0.26	0.10	0.67	0.15	1.58
Fig. 3b (colour cut)	2.19	0.49	0.09	0.62	0.14	0.79
Fig. 3c (Sèrsic +colour)	2.40	0.49	0.14	0.62	0.04	0.55
Fig. 3d (morphology)	1.70	0.50	0.14	0.78	0.05	1.67
S03	3.47	0.56	-	-	-	-

Table 1: Fitting parameters to equations 1 and 2 for the local early and late type MSR.

APPROACH

Until now the MSR found by Shen et al. (2003) (S03), based on SDSS data, has been used as the local standard. However, GAMA (the Galaxy And Mass Assembly survey; Driver et al. 2011) is a spectroscopic survey 2 magnitudes fainter than SDSS and thus allows us to extend the MSR to lower masses up to a decade smaller than S03 (down to $10^{7.6}M_\odot$).
Figure 2 shows the bimodal nature of local galaxies (see also Taylor et al. 2013), with the galaxy masses based on *ugriz* photometry (Taylor et al. 2011) and the sizes based on 2D Sérsic fits using SIGMA (Kelvin et al. 2011).

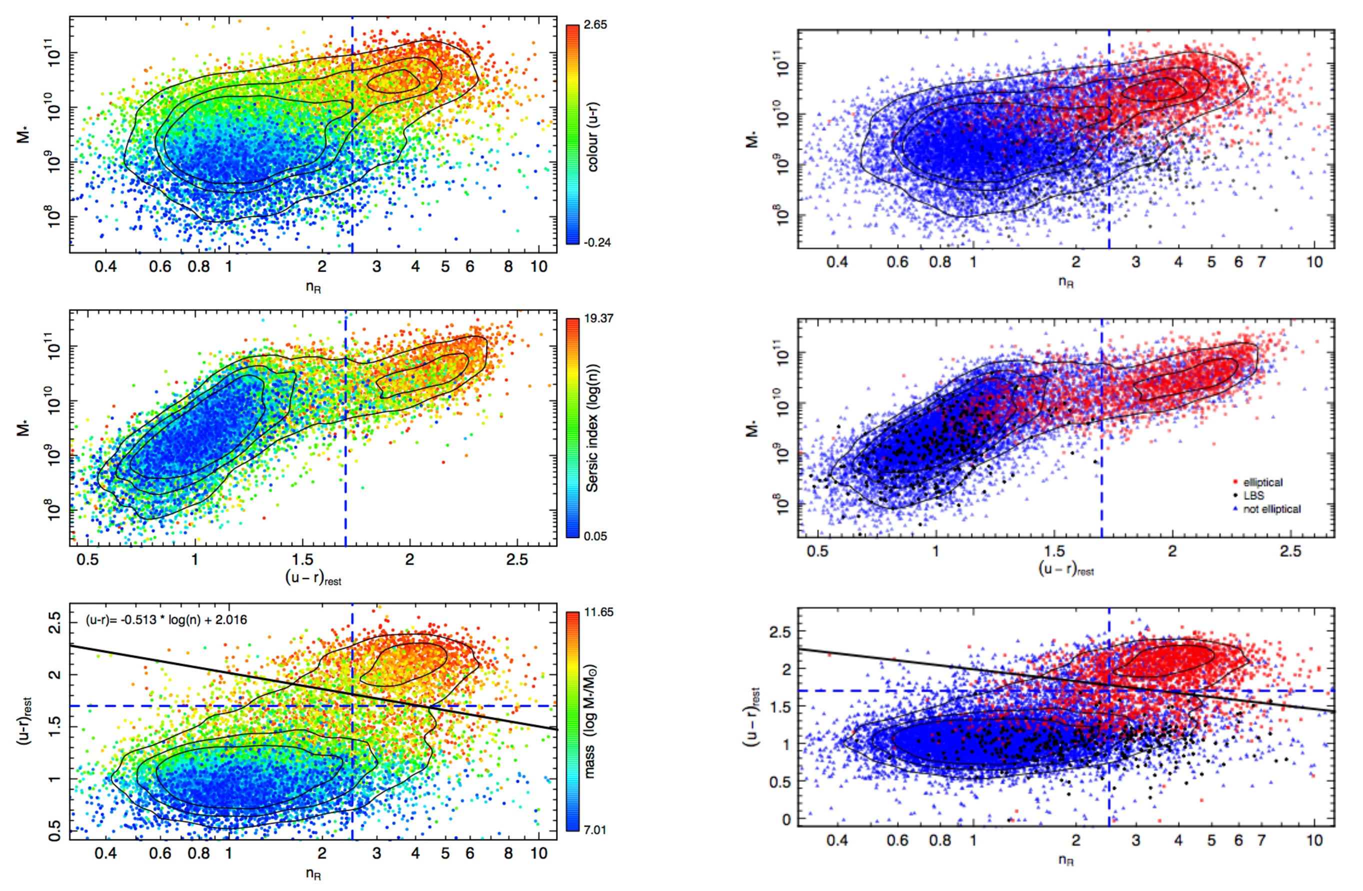


Figure 2: Population separation criteria for the MSR for GAMA galaxies with 0.014<z<0.1 and r_{pet}<19.4, as a 3D distribution on the left and coloured according to morphology on the right.
From top to bottom the cuts shown are: a) Sérsic index cut, b) $(u-r)_{rest}$ colour cut and c) combined Sérsic index and $(u-r)_{rest}$ colour cut.
The blue dashed lines show the hard cuts adopted for Sérsic index (n=2.5) and colour (u-r=1.7) and the solid black line is the rolling Sérsic index and colour cut.

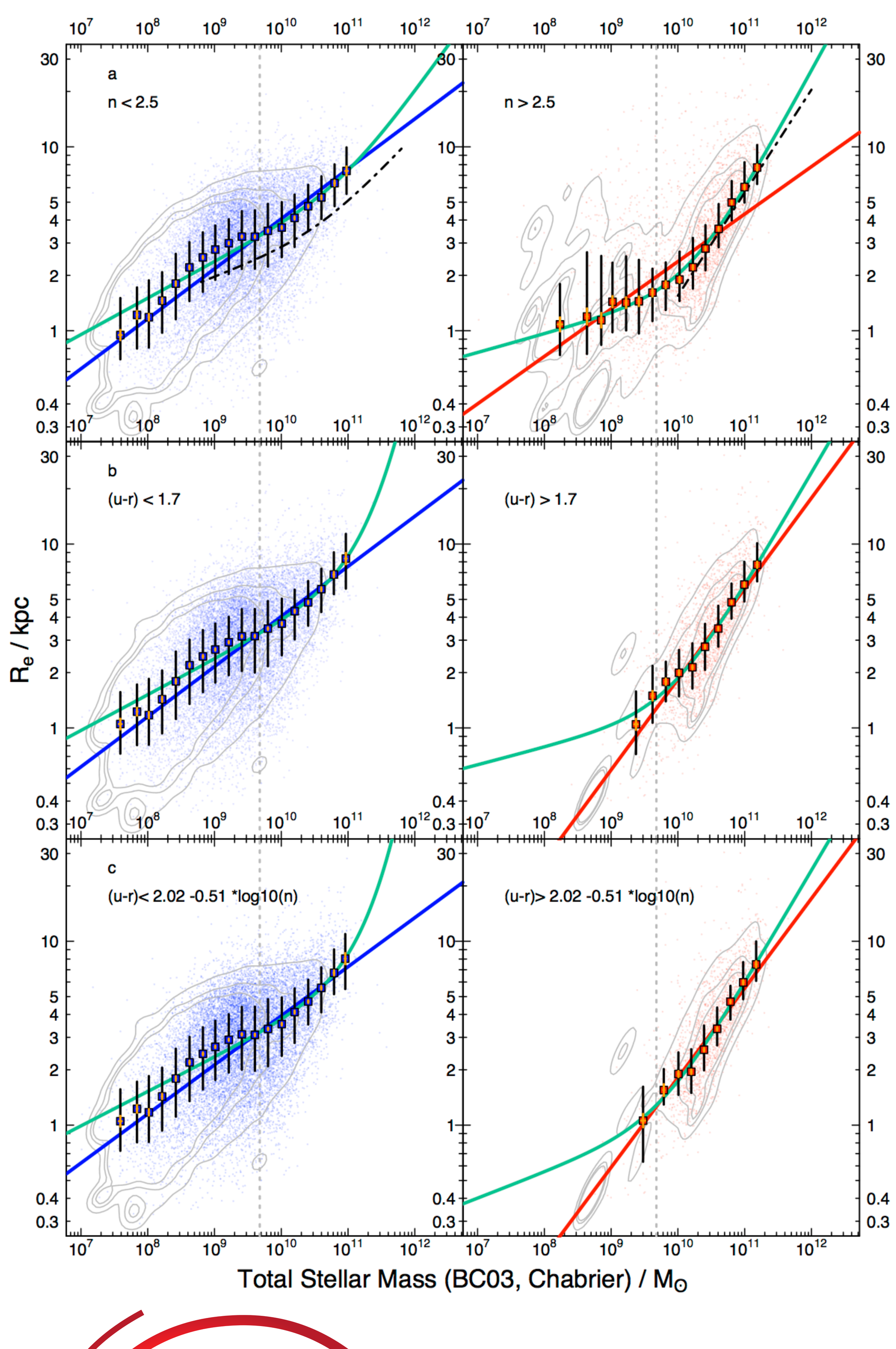
ANALYSIS

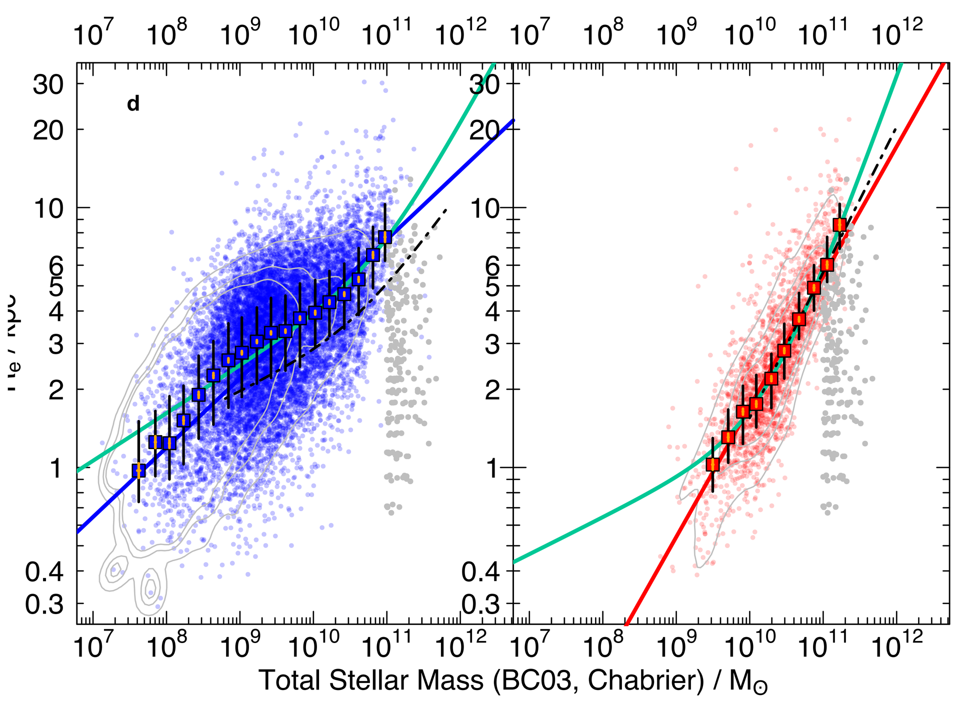
Figure 3 shows the result of our (r band) measurement of the MSR with the relation for late types on the left (in blue) and early types on the right (in red). Using quantile regression and $1/V_{max}$ weighting we fit two lines to each sample:

1) $$R(kpc)=a\left(\frac{M_*}{M_{sun}}\right)^b$$

2) $$R(kpc)=\gamma\left(\frac{M_*}{M_{sun}}\right)^\alpha\left(1+\frac{M_*}{M_0}\right)^{\beta-\alpha}$$

where R(kpc) is the half-light radius in kpc, M_* is the total stellar mass of a galaxy and M_0 is a 'transition mass' between low and high mass galaxies. Both equations are of the same form as the fits in S03 so that the fitting parameters can be compared (see Table 1).





igure 3: The local MSR for early (red) and late (blue) ype galaxies (for fitting parameters see table 1). The olid squares are median size and mass data points for each bin. With the bins being at least 0.2 log ($M_*/M_\odot$) vide and consisting of more than 50 data points. The ed and blue lines are the fits to equ.1 and the green ne is the fit to equ.2, the black dot-dashed lines are he S03 relations.
he following population separators were used:
a) n=2.5
b) $(u-r)_{rest}$=1.7
c) combined Sérsic index and colour cut
d) morphology, the points are coloured according to the rhs of Fig.2 and the grey points shown here are high redshift data points from Bruce et al. (2012) illustrating the growth of galaxies since redshift ~3 (no differentiation of ellip/not ellip).

CONCLUSION

Our analysis shows that, with the exception of the Sérsic index, the MSR is robust to the slight changes in population introduced by the different separators. The Sérsic index cut is skewed by a population of Little Blue Spheroids (LBS) which causes the Early types MSR to flatten at low masses.
A more in depth analysis can be found in Lange R. et al (in prep.), which will also include the analysis of the MSR of disk and spheroid components.

FUTURE ANALYSIS

Eventually we look to trace the evolution of disks, spheroids and bulges out to z~1 in detail and further where possible across GAMA, COSMOS and ERS to test the two-phase model of Driver et al. (2013). This unprecedented sample will be analysed using the same software and techniques throughout and range from redshift z=0 to z=6 and span galaxy stellar masses from 10^8-$10^{11}M_\odot$.

ADDITIONAL DATA

The data analysis was done in 9 imaging bands available within GAMA: *ugriz*YHJK. The results of this analysis can be found in Lange et al. (in prep.). A preview of the fits can be found online by scanning the top QR code. This shows the quantile regression fit to LBS (green), late types (blue) and early types (red).

In addition we have tested SIGMA on ERS data (Windhorst et al. 2011) and the first preliminary results can be found by scanning the bottom QR code.
This animated gif shows the size v mass on the left hand plot and mass v lookback time on the right. By binning the ERS data in 1Gyr steps we then show the ERS sizes in comparison to the local MSR and the high-z data from Bruce et al. (2012).

MSR for *ugriz*YJHK bands

Preliminary high-z comparison

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