Galaxy and Mass Assembly (GAMA): Evolution of the mass-size relation

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Outline

- GAMA update
  - GAMA I
  - GAMA DR2
  - GAMA II

- Luminosity function
  - Joint stepwise maximum likelihood method
  - Luminosity function and evolution by Sersic type

- Multivariate distribution functions
  - Bivariate brightness distribution (BBD)
  - Luminosity-size relation
  - Mass-size relation

- Summary
  
  All results here are preliminary!
  Assume $h = 1$
GAMA Fields
GAMA-I (Driver et al. 2011)

- Three 12 x 4 deg fields
  - G09, G15 to $r = 19.4$
  - G12 to $r = 19.8$
- SDSS, UKIDSS-LAS $ugrizYJHK$ aperture matched and Sersic photometry (Hill et al. 2010, Kelvin et al. 2012)
- GALEX FUV, NUV photometry
- 130,301 spectra yielding 98% reliable redshifts (111,655 new)
- Derived parameters:
  - Spectral line and SFR measurements
  - Stellar mass estimates (Taylor et al. 2011)
  - Local density measurements
  - Group catalogue (Robotham et al. 2011)
- 32 refereed publications
GAMA Data Release 2 (Liske et al. in prep.)

- Provides GAMA-I data to $r = 19.0$ (G09, G12), $r = 19.4$ (G15)
- 72,225 objects, 98% with reliable redshifts
- Available since May 2013 from http://www.gama-survey.org/dr2/
  - SQL interface to catalogues
  - Single object viewer
  - Links to images, spectra
GAMA-II

- Four 12 x 5 deg fields to $r = 19.8$: G09, G12, G15, G23
- Smaller area (tbd) in G02
- Fully automated redshifts
- Equatorial regions (G09, G12, G15) now complete:
  - 183,010 galaxies with reliable redshifts (96.7% success rate)
  - Mean redshift $z = 0.23$

- Derived parameters (stellar masses, groups, environment) in progress
Luminosity function

- Use Cole (2011) joint stepwise maximum likelihood (JSWML) method
- Radial density fluctuations $\Delta(z_i)$ and luminosity function $\Phi(M_j)$ fit jointly along with luminosity ($Q$) and density ($P$) evolution parameters:
  - $M_c(z) = M + Qz$
  - $\Phi^*(z) = \Phi^*(0) \times 10^{0.4Pz}$
- Iteratively solve for $\Delta(z_i)$, $Q$, $P$ by minimising slope of straight line fit to $\Delta(z_i)$
  - Need tight prior on $P$ to achieve convergence
- Use $\Delta(z_i)$ to find density-corrected $V_{\text{max}}$ for each galaxy $\rightarrow$ LF $\Phi(M_j)$
- Fit for $\Delta(z_i)$, $Q$, $P$ using $r$-band Petrosian magnitude (GAMA selection band); K-corrections from SED fits using KCORRECT
- For subsequent multivariate distributions, keep $Q$, $P$ fixed, fitting only for $\Delta(z_i)$ and $\Phi(M_j)$
- Evolution correction applied only to luminosity
GAMA-II $r$-band LF

$\Delta(z)$ vs Redshift $z$

$\Phi(M)/h^3$ Mpc$^{-3}$

- $\alpha = -1.13 \pm 0.01$
- $M^* = -20.74 \pm 0.22$
- $\log \phi^* = -1.89 \pm 0.01$
- $P = 0.05 \pm 0.02$
- $Q = 1.12 \pm 0.08$
GAMA-I $r$-band LF Split by Sersic index

$n > 1.9$

$\alpha = -0.62 \pm 0.17$

$M^* = -20.76 \pm 0.10$

$log\phi^* = -2.12 \pm 0.05$

$P = 0.00 \pm 0.01$

$Q = 0.96 \pm 0.12$

$n < 1.9$

$\alpha = -1.29 \pm 0.10$

$M^* = -20.24 \pm 0.15$

$log\phi^* = -2.07 \pm 0.07$

$P = 0.08 \pm 0.03$

$Q = 1.54 \pm 0.15$
Multivariate distribution functions (GAMA-I)

- Always have SDSS Petrosian $r$-band magnitude as a parameter
- Other parameters:
  - Sersic $r$-band $10 R_e$ magnitude and effective surface brightness
  - Circularised effective radius
  - Stellar mass
- Advantages of Sersic over Petrosian:
  - Elliptical apertures
  - Seeing corrected
  - Larger fraction of flux measured
- Map redshift completeness in bins in multidimensional parameter space, also including estimated imaging completeness (Blanton et al. 2005)
- Sum over parameters not of interest
Bivariate brightness distribution (BBD)

- Choloniewski function v poor fit ($\chi^2/\nu \sim 15$)
- Sersic BBD much broader than Petrosian
- NB imaging completeness correction $> 2$ for $\mu_r \approx 23$ mag arcsec$^{-2}$

$V = 1800 \ h^{-3} \text{Mpc}^3$

$N_{\text{gal}} = 16$
Sersic BBD sliced by magnitude
• Sersic BBD broader than Petro
• Shows maximum SB $\mu_r \approx 20$ mag arcsec$^{-2}$ at $M_r \approx -21$ mag
• Petro SB of most compact galaxies underestimated by seeing?
• From now on just show Sersic parameter results
Luminosity-size relation by Sersic index

$n < 1.9$

$n > 1.9$
Luminosity-size relation by Sersic index
Evolution of luminosity-size relation

- No size evolution for exponential-profile galaxies
- For de-Vauc profile galaxies, $R_e$ has increased by $\sim 10\%$ since $z \sim 0.2$
Mass-size relation by Sersic index

$n < 1.9$

$n > 1.9$
Mass-size relation by Sersic index

\[ n < 1.9 \]
\[ n > 1.9 \]
In fixed mass bins, exponential-profile galaxies were larger in the past (fading?)

For de-Vauc profile galaxies, \( R_e \) has increased by \( \sim 10\% \) since \( z \sim 0.2 \)

NB no mass evolution assumed
Summary

- GAMA-II $r$-band LF well fit by evolution model with $Q = 1.12$, $P = 0.05$
- BBD not well fit by Choloniewski function
  - SB peaks at $\mu_e = 20$ mag arcsec$^{-2}$ for $\sim L^*$ galaxies
  - SB distribution broadens at fainter luminosities
- (e-corrected) luminosity-size distribution:
  - No sig evolution for late-type galaxies
  - Early-types grow by $\sim 10\%$ since $z \sim 0.2$
- (Non e-corrected) mass-size distribution:
  - Late-type galaxies larger in past in fixed mass bins
  - Early-types grow by $\sim 10\%$ since $z \sim 0.2$
- Future work:
  - Apply to GAMA-II dataset, later VST KIDS imaging
  - Interpolate radius to fixed restframe band
  - Investigate environmental dependence