Galaxy And Mass Assembly: LF for Galaxies in Groups

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GAMA

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1 Abstract

Using the GAMA-I group catalogue, we estimate the galaxy luminosity function for galaxies in groups in intervals of redshift and mass, in order to understand the evolutionary processes of these systems. Luminosity functions are estimated in the SDSS optical r-band and are fitted with evolutionary power-law Schechter functions. This study will contribute to understanding the connection between galaxies and their distribution in dark matter halos. In this poster, preliminary results are presented.

2 Introduction

The distribution of galaxies in space is actually strongly clustered and a large fraction of the galaxies are prone to forming gravitationally bounded multiple systems, from very populated clusters to loose groups, with the majority being in normal groups.

ΛCDM model predicts the hierarchical merging process that occurs between haloes of dark matter (DM) in the structure formation paradigm. Galaxy groups represent the observational part of the DM haloes which are able to say something about the physics in these haloes, but galaxy groups also provides a route to studying dark matter dynamics (e.g. Robotham et al. 2008) and how galaxies populate halos (Robotham et al. 2010b).

Galaxy luminosity functions (LFs) provide a means of comparison between the population of galaxies of various luminosities in different environments, and contain valuable information about the physical process that feature prominently in galaxy formation. LF and its evolution provide important constraints on theories of galaxy formation and evolution as well.

3 Data

This work has been carried out using the GAMA Galaxy Group Catalogue (Robotham et al. 2011). This catalogue has been compiled using the galaxies from the Galaxy and Mass Assembly (GAMA) survey (Baldry et al. 2010).

Briefly, GAMA is a major new multi-wavelength spectroscopy galaxy survey (Driver et al. 2011) with ~400 000 galaxies redshifted in three 4x12 degree regions centred approximately on the equator and at right ascensions of 9, 12 and 14.5 hours. These fields are called G09, G12 and G15 respectively. Magnitude limits are r<19.4 mag in the G09 and G15 fields while r<19.8 mag in the G12 field.

GAMA Galaxy Group Catalogue (G^3Cv1) was generated using a friend-of-friends (FoF) based grouping algorithm. This Catalogue contains 14,388 galaxy groups (with multiplicity ≥ 2), including 44,186 galaxies out of a possible 110,192 galaxies (Robotham et al. 2011). Figure 1 shows the distribution of the groups onto the equatorial plane in the three GAMA regions.

Data from the G^3Cv1 and the Sloan Digital Sky Survey (SDSS) were matched in order to have the Petrosian and model magnitudes with their errors in all five SDSS passbands to determine the K-corrections.

To estimate LFs, Petrosian magnitudes were corrected for Galactic extinction.

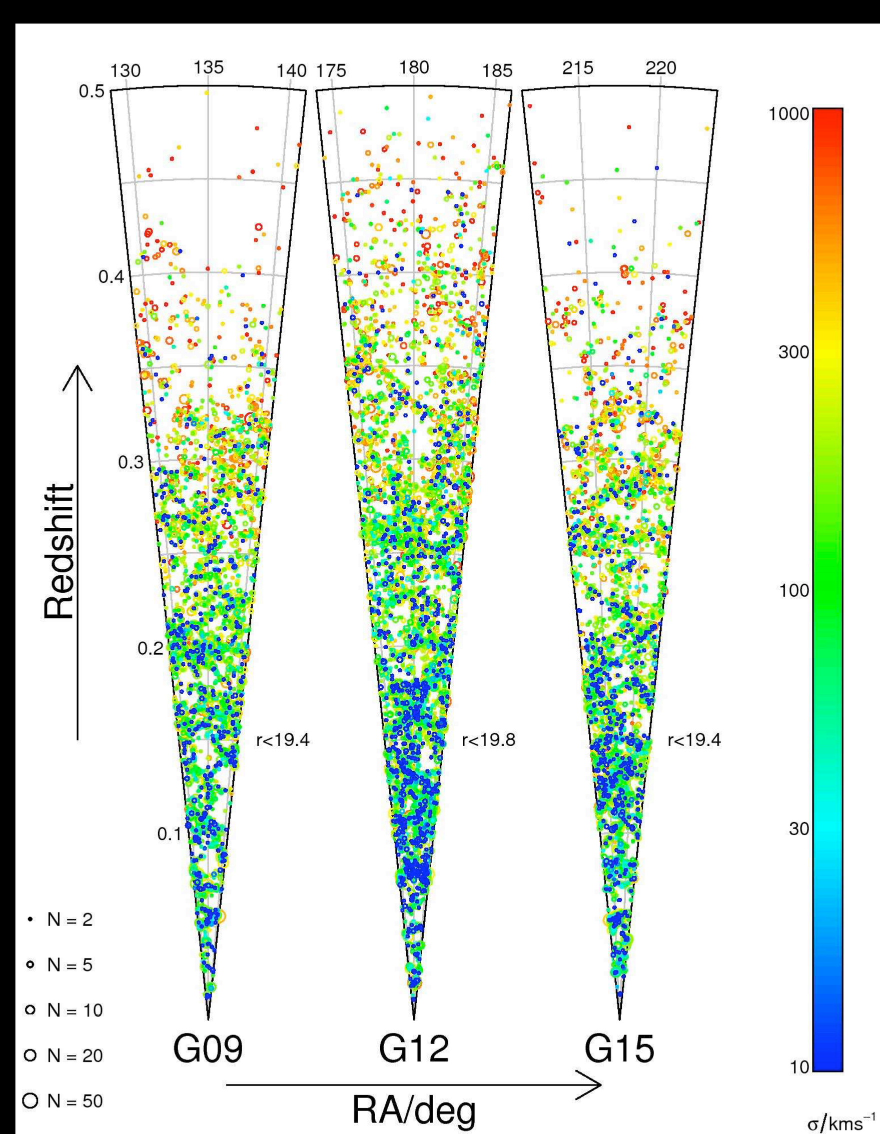

Figure 1. Redshift space position of GAMA galaxy groups projected onto the equatorial plane, split by survey area and with symbol size reflecting the group multiplicity and symbol colour the group velocity dispersion. (Robotham et al. 2011)

4 Optical Luminosity Function

LF estimation requires a completed sample. G^3Cv1 has a high spectroscopy completeness due to the spectroscopy completeness in GAMA (> 98 per cent, Driver et al. 2010). A small level of incompleteness is likely to preferentially affect low surface brightness galaxies.

LFs are estimated using the $1/V_{max}$ (Schmit 1968) and stepwise maximum likelihood (SWML, Efstathiou, Ellis & Peterson 1988) methods.

A limit magnitude of r<19.4, 60 magnitude bins from M = -25 to M = -10 with ΔM = 0.25, four redshift bins [0.002, 0.1], [0.1, 0.2], [0.2, 0.3], and [0.3, 0.5], and two mass bins [$M < 10^{13}M_\odot$] and [$10^{13}M_\odot < M$] were used.

When estimating the LF over restricted redshift ranges, it is important to include magnitudes bins that are fully sampled, since otherwise the LF will be underestimated in incomplete sample bins. So, the magnitude limits for each slice were set such that only complete bins are included, namely

$$M_{faint} < m_{faint} - DM(z_{lo}) - K(z_{lo}),$$
$$M_{bright} < m_{bright} - DM(z_{hi}) - K(z_{hi}),$$

where m_{faint} and m_{bright} are the flux limits of the survey. The distant modulus is given by $DM(z)$, $K(z)$ is the K-correction, and z_{lo} and z_{hi} are the limits of the redshift slice under consideration. The M_{faint} and M_{bright} denote the absolute magnitude limits of each bin.

	Ngal	φ*	M *	α
Combined				
Not group	55551	0.0001 ± 9E-07	-20.26 ± 0.01	-1.179 ± 0.01
<13	11105	8.91E-05 ± 7E-07	-20.47 ± 0.04	-0.919 ± 0.02
>13	23449	6.94E-05 ± 5E-07	-20.89 ± 0.03	-1.01 ± 0.02
Blue				
Not group	29839	7.26E-05 ± 7E-07	-19.96 ± 0.03	-1.38 ± 0.02
<13	5184	3.78E-05 ± 4E-07	-20.20 ± 0.06	-1.22 ± 0.03
>13	8050	2.28E-05 ± 2E-07	-20.31 ± 0.06	-1.34 ± 0.03
Red				
Not group	25712	0.0001 ± 1E-06	-19.90 ± 0.02	-0.38 ± 0.03
<13	5921	9.65E-05 ± 7E-07	-20.11 ± 0.03	-0.23 ± 0.03
>13	15399	9.38 E-05± 6E-07	-20.72 ± 0.03	-0.67 ± 0.02

Table 1. Evolving Schechter function fits to r-band, different colour and masses for grouped and ungrouped galaxies luminosity functions.

5 LF evolution

To parameterize the evolution of the galaxy luminosity function, Lin et al. (1999) is followed, assuming a Schechter (1976) function in which the characteristic magnitude M^* and galaxy density can vary with redshift, but not the faint-end slope α. Schechter function is given by

$$\phi(M) = 0.4 \ln 10\, \phi^*(10^{0.4(M^*-M)})^{1+\alpha} \exp(-10^{0.4(M^*-M)}),$$

where the Schechter parameters α, M* and φ* vary with redshift as

$$\alpha(z) = \alpha(z_0),$$
$$M^*(z) = M^*(z_0) - Q(z - z_0),$$
$$\phi^*(z) = \phi^*(0)10^{0.4Pz}.$$

The redshift z_0 is the same redshift to which magnitudes are K-corrected (z_0 = 0.1). The Schechter parameters α, M*(z0) and φ*(0) and evolution parameters Q and P are determined via the maximum-likelihood method described by Lin et al. (1999). The shape parameters α, M*(z0) and luminosity evolution parameter Q are fitted simultaneously and independently of the other parameters using a generalization of the method of Sandage, Tammann & Yahil (1979). Then the number density evolution P is fit according to Lin et al. (1999)

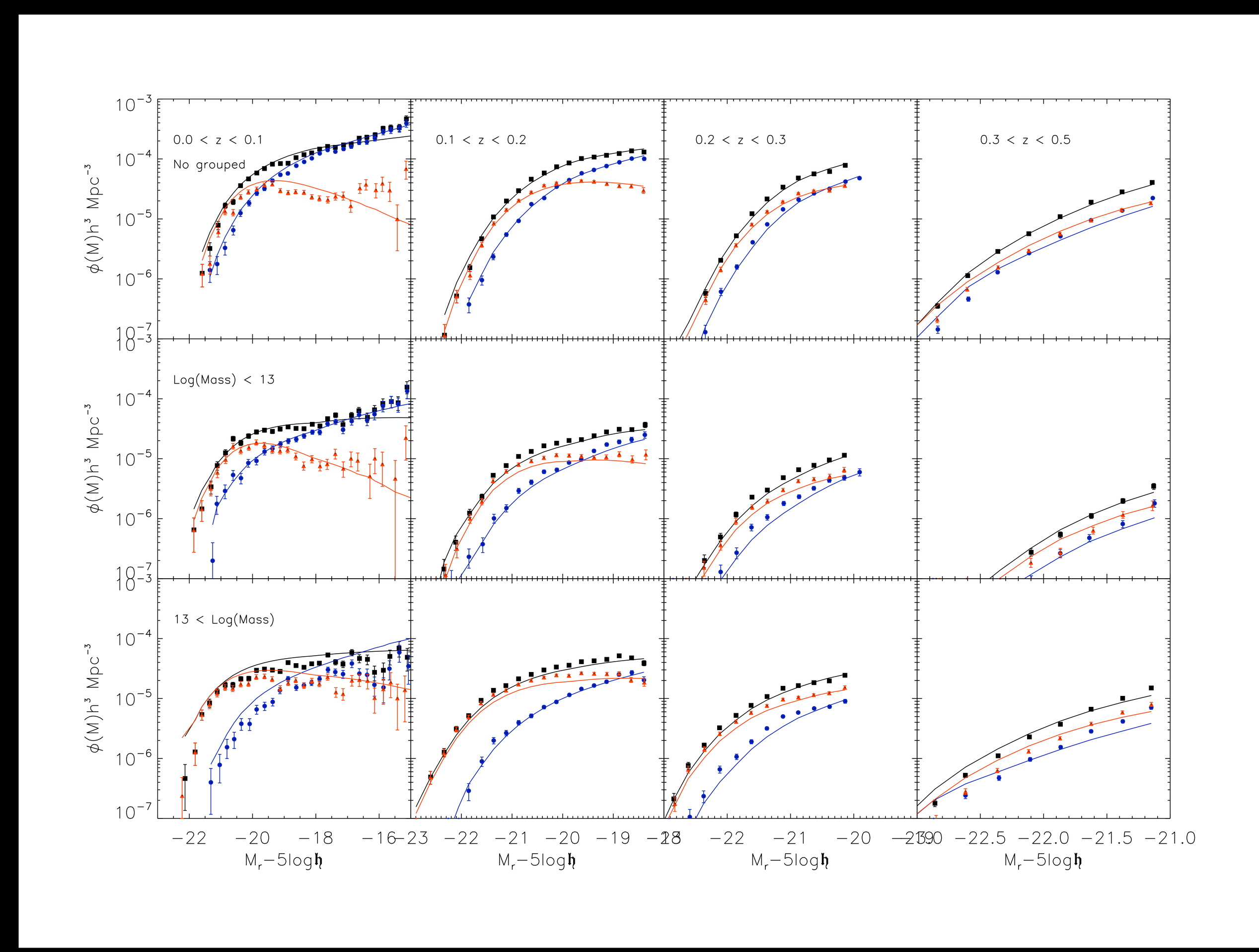

Figure 2. Evolution of the r LF estimated by $1/V_{max}$ method. The four columns the LFs in four redshift ranges increasing from left to right. The three rows show the LFs for GAMA ungrouped galaxies on the top and galaxies in groups divided in two ranges of masses. Black squares show the LF estimation for combined red and blue samples, blue circles and red triangles show the LFs for the blue and red samples respectively. Continuous lines show the parametric evolving LF for each sample.

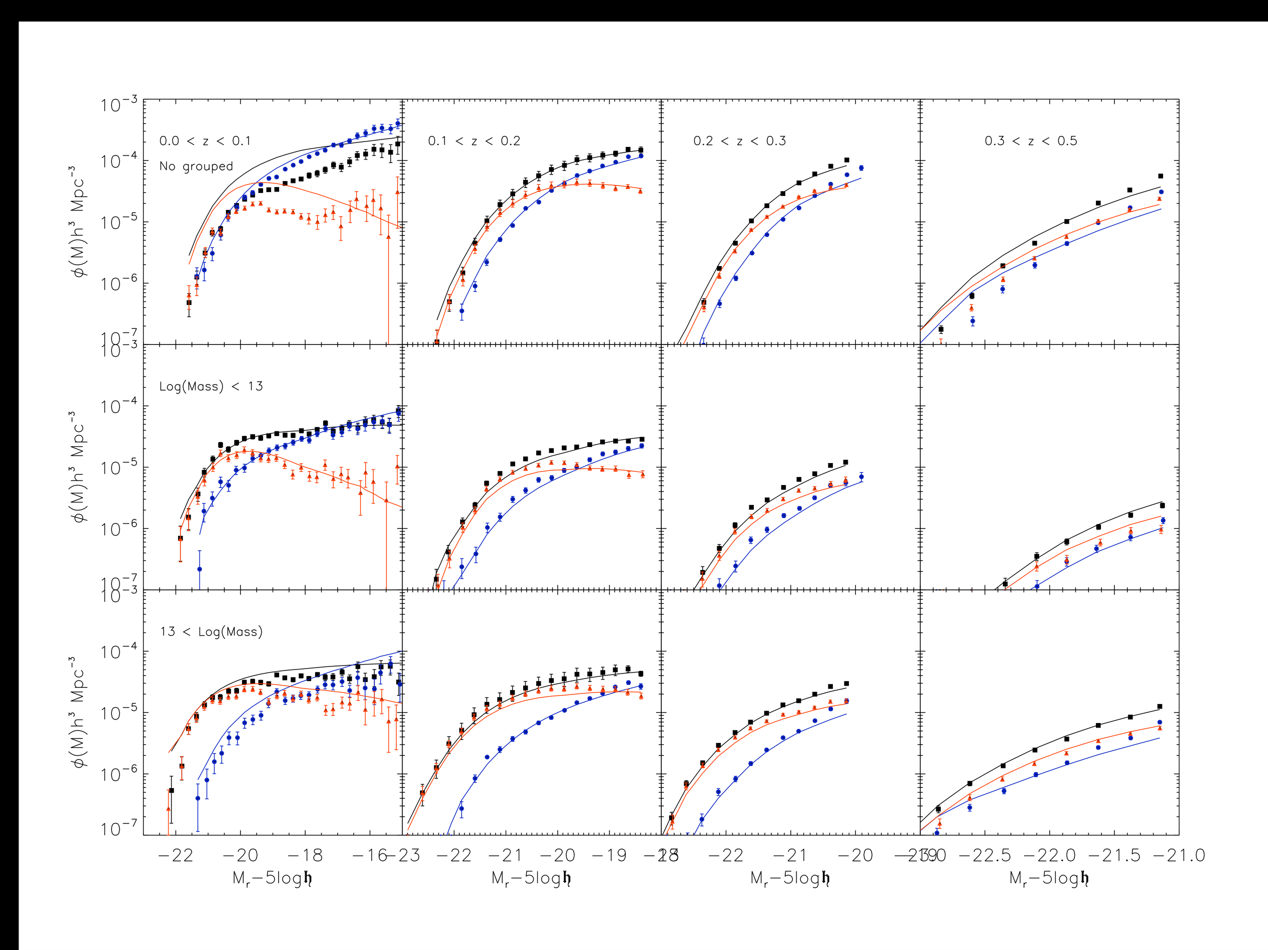

Figure 3. As Fig. 2 but showing SWML estimates of the luminosity function.

6 Results

Luminosity functions are presented for the combined, blue and red samples in the r-band in four redshift ranges and two masses ranges for groups, and also for ungrouped galaxies, using the $1/V_{max}$ estimator (Fig. 2) and the maximum-likelihood method (Fig. 2).

There are no important differences between the LFs estimators, except for ungrouped galaxies at low redshift where blue galaxies show φ values higher than combined colours, and the parametric evolution model fits very poorly with data.

Over the masses and redshift ranges shown, LFs are well-fitted by the parametric evolution model at masses < $10^{13}M_\odot$ and redshifts up to 0.3. However, at higher masses and high redshifts a discrepancy between the LFs and the model can be seen.

It is important to note the lack of blue galaxies in the brightest region as well as an over density at the faint end.

Table 1 gives the number of galaxies and Schechter parameters in each color and mass for galaxy groups and galaxies not grouped, shown without redshift ranges.

7 Conclusions

Preliminary measurements of the LF for galaxies in groups from the GAMA Galaxy Group Catalogue in the r-band are presented.

Due to the great quantity of information in GAMA, it is possible to estimate the LF using multiple constraints and to determine the different evolved states of galaxies in different environments.

A detailed estimation of LF for galaxies in groups is being carried out taking the five SDSS passbands and non-optical bands, as well as using different parameters to constrain and establish a connection between galaxies and their distribution in dark matter haloes, and also to constrain cosmological models.

8 References

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