# The brightest group galaxies and their large-scale environment

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**Resumen** / Estudiamos las galaxias más luminosas (del inglés *Brightest Group Galaxy*, BGG) de una muestra de grupos de galaxias en el SDSS, discriminando submuestras de grupos según su estructura circundante en gran escala. Encontramos que las propiedades de las BGG dependen del ambiente en gran escala, caracterizado por su pertenencia a los picos de densidad dentro de estructuras virializadas en el futuro (del inglés *Future Virialized Structures*, FVS). Los valores de luminosidad, índice de color, masa estelar e índice de concentración de las BGG alojadas en grupos en FVS difieren con significancia estadística de aquellas que no se encuentran en superestructuras. Esta señal está dominada por galaxias tipo disco. Estos resultados revelan conexiones entre la estructura en gran escala y los procesos de aglomeración de masa en grupos de galaxias.

**Abstract** / We use a sample of galaxy groups in SDSS data to study their brightest galaxies (BGG), separating groups according to their large scale environment. The statistical properties of the BGG depend on the surrounding environment on large scales, characterized by the high density peaks within *Future Virialized Structures* (FVS). We also find that the luminosity, colour, stellar masses and concentration index of the BGG hosted by groups in superstructures are different, with statistical significance, from the corresponding properties of BGG hosted by groups elsewhere. Moreover, this signal is strongly dominated by disk-type galaxies. The results reveal connections between the large scale environment and the accretion process onto the brightest group galaxies.

*Keywords* / methods: statistics — methods: data analysis — Large-scale structure of the Universe

## 1. Introduction

Recent galaxy surveys of the surrounding Universe delineate a complex network of filaments and voids (e.g. Jaaniste et al., 2004; Einasto, 2006) that make up the foundations of the large–scale structure and the formation and evolution of galaxies and galaxy systems. The highest density large–scale regions, usually named superclusters, are preferentially located at the intersections of filaments and host most of the galaxy associations, like groups or clusters. Galaxy properties result from a number of factors, mainly dynamical processes in the local environment, which have been widely studied in the context of galaxy groups (e.g. Blanton et al., 2003; Balogh et al., 2004; Kauffmann et al., 2004; Baldry et al., 2006; Muzzin et al., 2012; Hou et al., 2013). Yet, the hierarchical structure formation model states that the distribution of matter evolves from small fluctuations in the early Universe to form the complex observed large–scale configuration (see e.g. Bardeen et al., 1986, and references therein), so that the role of the large scale on galaxy evolution is more subtle and less analysed. Here we present a study of the effects of superstructures on the brightest group galaxies, independently of the local environment given by group total luminosity (a proxy to mass).

## 2. Data sample and methods

In order to analyse the galaxy groups properties, we use data from galaxy catalogs derived from the Seventh Data Release of the Sloan Digital Sky Survey (SDSS-DR7, Abazajian et al., 2009). We define environments at two scales: the local environment, characterized by the properties of galaxy groups (Zapata et al., 2009); and the global environment, mapped by Future Virialized Structures from the catalog of Luparello et al. (2011). We isolate the global environment effect over galaxies in groups, by selecting galaxy group samples at total r-band luminosity bins (to disentangle the local effects) and comparing different locations in the large-scale structure. We are particularly interested on studying the dependence of the brightest group galaxy (BGG) of groups, which is known to depend on the properties of the host group. Taking this into account, we characterize the BGGs according to their Sérsic index n, distinguishing late-type BGGs ($n < 3.5$) and early-type BGGs ($n > 3.5$). With these criteria, we define four samples of galaxies in groups according to the type of their brightest galaxy and their large-scale environment: groups dominated by early-type BGGs, and groups dominated by late-type BGGs, inside and outside superstructures respectively.

We restrict our analysis to bins of same total group luminosity (a proxy of mass) inside and outside FVS, in order to quantify the large–scale environment depen-

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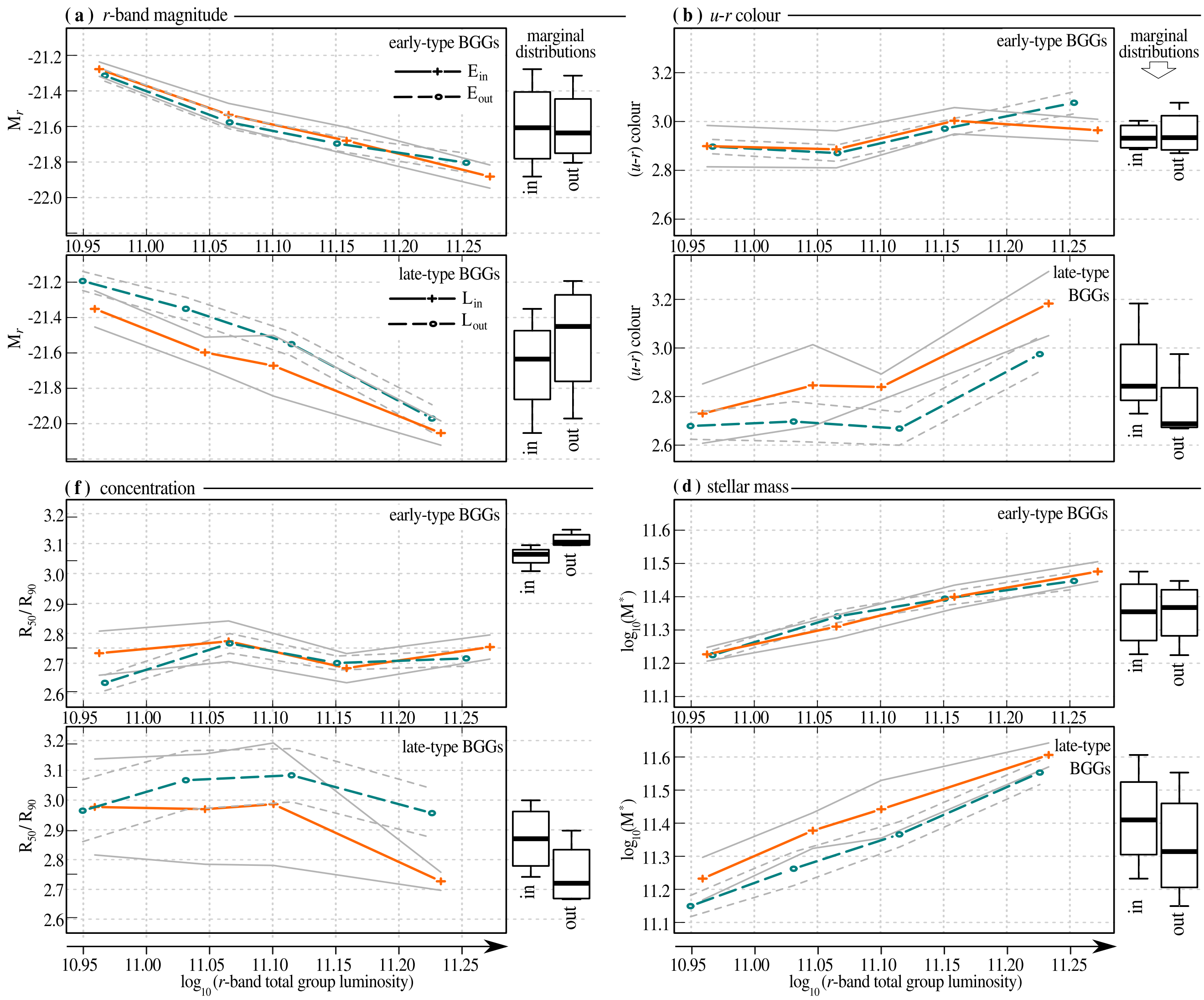


Fig. 1: Averaged properties of early-type (upper subpanels) and late-type (lower subpanels) BGGs in FVS (solid lines) and elsewhere (dashed lines), as a function of total group luminosity. 1-sigma uncertainties are shown with solid and dashed gray lines, respectively. The properties shown in this figure are a) r-band magnitude, b) u-r colour, c) concentration index, and d) stellar mass. In all panels $L_{in}/L_{out}$ and $E_{in}/E_{out}$ refer to late-type BGGs within/outside FVS and early-type BGGs within/outside FVS, respectively. Box plots on the right hand side of each panel show the quartiles and extrema of the correponding marginal distributions.

dence regardless the host group luminosity. In Figure 1 we show the mean values of absolute magnitude in the r–band, u-r colour, concentration parameter R50/R90 and stellar mass of BGGs, in panels (a) to (d) respectively, as a function of group total luminosity, and consider departures from the mean values of such properties at a given group luminosity interval. In general, the difference between groups in FVS and groups not belonging to FVS is noticeable with a $1-\sigma$ significance level, for the samples of groups with a late type BGG, all over the total group luminosity range (lower subpanels of Figure 1). In order to quantify these differences, we perform a linear fit of each property as a function of group luminosity, for the full sample, so that any trend on the mean of the residual values inside and outside FVS can be considered as an indicator of large–scale effects. We then estimate the residuals of the fit, separately for the galaxies inside and outside FVS. The procedure is shown in Figure 2, for the case of r–band absolute magnitude of BGGs, where we explicitly plot the residuals of galaxies in FVS (orange) and elsewhere (blue). The mean and the standard deviation of the distribution of residuals of the r-band absolute magnitude, u-r colour, concentration index $R_{50}/R_{90}$ and stellar mass are shown in panels (a) to (d) of Figure 3. It can be seen that in most cases late–type BGGs exhibit more significant differences according to their the large–scale environment while early–type BGGs are likely to belong to a common population. More details concerning data selection and methods are given in Luparello et al. (2013)

and Luparello et al. (2014).

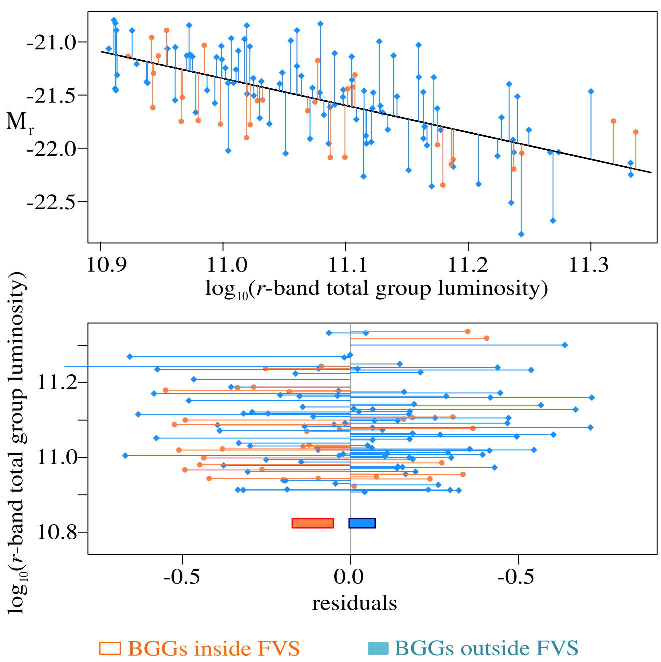


Fig. 2: Upper panel: scatter plot of the late-type BGGs absolute magnitud in the r- band vs. group total luminosity. The linear fit corresponds to the complete sample. Blue dots represent BGGs outside FVS and orange dots BGGs inside FVS. Lower panel: distribution and mean values of residuals of the linear fit for BGGs outside FVS (in blue) and BGGs inside FVS (in orange).

## 3. Results

We find that late–type BGGs inhabiting superstructures show, higher luminosities and higher stellar mass, at roughly 10 per cent excess. Colors show a difference of means of 0.11 towards red. These differences are negligible when considering lower luminosity galaxies, and only found in late–type BGGs. We argue that these observations provide evidence on the particular role of the BGG on the formation history of galaxy systems. The observed signals support a scenario where the gas accretion via mergers into the BGG is more important when the groups are located outside FVS, and with a significantly larger fraction of dry mergers compared to wet mergers, occuring onto BGGs in FVS. The accretion of gas onto the BGG could be more efficient outside FVS, explaining the differences on late-type galaxies. Although this effect could also be present on early–type BGGs, their older ages could have erased the effect on these objects. The effects of the FVS environment over low ranked galaxies is negligible, possibly because the accretion occuring in groups inhabiting FVS could be dominated by local dynamical processes, such as galaxy harassment and gas extrangulation.

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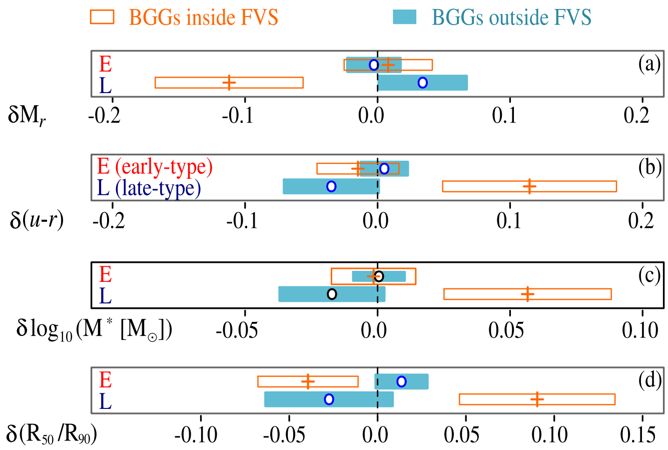


Fig. 3: Mean residuals and their standard errors for early-type (E) and late-type (L) BGGs. The residuals are computed for (a) Mr-band luminosity, (b) u-r colour index, (c) stellar mass and (d) concentration index. Empty boxes and cross symbols correspond to galaxies in groups within FVS (Ein and Lin samples), filled boxes and circles correspond to galaxies in groups outside FVS (Eout and Lout samples).

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