BCGs evolution in the last 6 Gyr: feedback processes versus merger events.

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We present results on the evolution in the last 6 Gyr of the structural parameters of two samples of brightest cluster galaxies (BCGs). The nearby sample of BCGs consist on 69 galaxies from the WINGS survey spanning a redshift range of 0.04<z<0.07. The intermediate redshift (0.3<z<0.6) sample is formed by 20 BCGs extracted from the Hubble Space Telescope archive. Both samples have similar spatial resolution and their host clusters have similar X-ray luminosities. We report an increase of a factor of 2 in the size of the BCGs from intermediate to local redshift. However, we do not detect any variation in the Sérsic shape parameter in both samples. These results are proved to be robust since the observed tendencies are model independent. We also obtain significant correlations between some of the BCGs parameters and the main properties of the host clusters. More luminous, larger and centrally located BCGs are located in more massive and dominant galaxy clusters. These facts indicate that the host galaxy cluster has played an important role in the formation of their BCGs. We discuss the possible mechanisms that can explain the observed evolution of the structural parameters of the BCGs. We conclude that the main mechanisms that can explain the increase in size and the non-evolution in the S\'ersic shape parameter of the BCGs in the last 6 Gyr are feedback processes. This result disagrees with semi-analytical simulation results supporting that merging processes are the main responsible for the evolution of the BCGs until the present epoch.

WINGS sample:

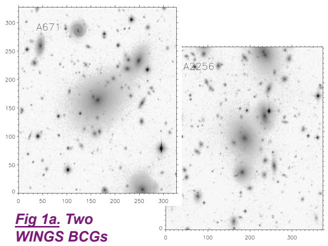


***Fig 1a.* Two WINGS BCGs**

- 77 BCGs located in local clusters 0.04 < z < 0.07 *(Fasano et al. 2006)*
- The clusters were selected from the X-ray ROSAT catalogues *(Ebeling et al. 1996)*
- Observed with WFC at the Isaac Newton Telescope (INT) at La Palma (Spain) and with WFI in Max Planck Gesellschaft (MPG-ESO)-2.2m in La Silla (Chile)
- Observed in B and V band under good seeing conditions (~1'')

ACS sample:

- 20 BCGs located in intermediate redshift 0.3 < z < 0.6 clusters
- The clusters are a subsample of the homogeneous sample of 72 X-ray clusters *(Mullis et al. 2003)*
- Observed with the Advanced Camera for Surveys (ACS) in Cycle 13 and 14 (proposals 10490 and 10152)
- Observed in F814W band in single pointings.

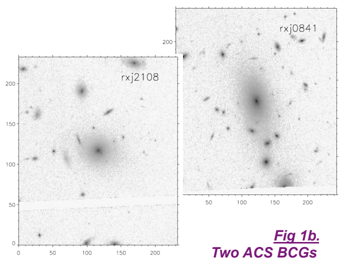


***Fig 1b.* Two ACS BCGs**

STRUCTURAL PARAMETERS

We fit the two dimensional surface brightness (SB) profiles of all the BCGs in the samples with two components (Sérsic+Exponential) by using Gasp-2D *(Mendez-Abreu et al. 2008).*

From these fits, we have obtained their structural parameters. We show in Table 1 their mean values.

	WINGS($z\sim0$)	ACS($z\sim0.5$)
$<n>$	2.64 ± 0.12	2.51 ± 0.32
$<r_e(\mathrm{kpc})>$	6.92 ± 1.40	3.35 ± 0.77
$<\mu_e(\mathrm{mag/arcsec^2})>$	20.29 ± 0.23	20.96 ± 0.26

***Table 1.* Mean values of the Sérsic parameter, effective radius and effective SB for the WINGS and ACS BCGs**

In Figure 2, we show the relation between absolute V rest-frame magnitude (M_V) of the fitted Sérsic component and the mean surface brightness, Sérsic parameter and effective radius of the BCGs. For a given luminosity, nearby BCGs have fainter μ_e, larger r_e and similar Sérsic parameter than the intermediate redshift BCGs sample.

We also find the same behaviour in the two BCGs samples. Brighter BCGs are larger (the *Spearman test* provides a significance level of 6.81 and 3.56 σ for the WINGS and the ACS sample respectively), having the lower redshift sample a steeper slope with respect to the intermediate redshift sample. BCGs in low redshift clusters have also a significant correlation between absolute magnitude and shape parameter (3.65σ significance in the Spearman test) and between absolute magnitude and mean effective surface brightness (4.79σ significance in the Spearman test). However, these tendencies are less significant for the intermediate redshift sample.

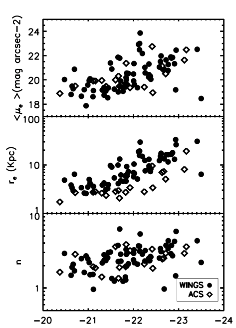


***Fig 2.* Absolute magnitude versus medium surface brightness, Sérsic parameter and effective radius for the BCGs in WINGS (black points) and ACS (diamonds)**

SIZES AND SHAPES EVOLUTION

In Figure 3, we show the relation between the shape parameter and the effective radius of the Sersic fitted component for the BCGs in both samples. In both cases, we see a trend in the sense that larger BCGs have larger Sérsic parameter.

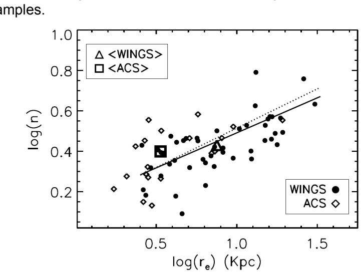
In addition, nearby BCGs are larger than intermediate redshift ones. We have performed a *Kolmogorov-Smirnoff (KS)* test resulting that

- the galaxy sizes distributions of the nearby and intermediate redshift samples **are statistically different**.

- the Sérsic parameter distributions of both galaxy samples **are not statistically different.**

The fact that the Sérsic parameter of the BCGs has not changed indicates that the central light concentrations of the BCGs are similar in both samples.

***Fig 3.* Relationship between size (re) and shape (n) for the BCGs in WINGS (black points) and ACS (diamonds). The solid and dotted lines show the fits to the WINGS and ACS samples respectively. The triangle and square show the medina value for the WINGS and ACS sample respectively.**



In the last 6 Gyr. the effective radius **has changed** by $r_e(z\sim0)/r_e(z\sim0.5) = 2.06\pm0.63$

In contrast, the shape Sérsic parameter **has not changed** being $n(z\sim0)/n(z\sim0.5) = 1.05\pm0.14$

These result are robust enough since they **do not depend** either on the number of components fitted or on the model we use.

CONCLUSIONS

Recently, it has been discovered than the Sérsic shape parameters of early-type galaxies has also evolved during the last Gyrs, being larger for nearby galaxies (*Vikram et al. 2009, Van Dokkum et al. 2010).* Indeed, although the mass of massive early-type galaxies has grown from z~2 until today, this mass growth has been focused on their external regions (*Van Dokkum et al. 2010).* These results have been interpreted as an inside-out growth of the early-type galaxies, assembling their extended haloes in the last Gyrs. There are several numerical simulations supporting those observed changes of the structural parameters of early-type galaxies. Thus, major or minor mergers produce a growth of the effective radius and Sérsic parameter of the *galaxy (Aguerri et al. 2001, Hopkins et al. 2010).*

Numerical simulations show that the structural parameters of early-type galaxies can change due to several processes. In particular, if a galaxy could loose a fraction of its central mass then the radius of the object will grow, and the system will keep the surface brightness profile shape (*Hopkins et al. 2010).* This process called adiabatic expansion could explain our observables for BCGs. The loss of the inner material could be due to different reasons. Among others, quasar feedback, central starburst produced by cooling flows observed in some BCGs or displacement of black holes from the galaxy.

In summary, according to our observations, the evolution of BCGs within the last 6 Gyrs **is driven by feedback processes rather than merger evolution** *(Ascaso et al. 2010).* This result is in contradiction with the results obtained by recent numerical simulations about the origin and evolution of BCGs *(de Lucia & Blaizot 2007).* These simulations predict an important mass growth of the galaxies via dry mergers in the last 6 Gyrs. Nevertheless, other observational recent works have also observed a small change of the mass of BCGs in the last 8 Gyrs *(Collins et al. 2009).*

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