UV TO FAR-IR CATALOG OF A GALAXY SAMPLE IN NEARBY CLUSTERS: SPECTRAL ENERGY DISTRIBUTIONS AND ENVIRONMENTAL TRENDS

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ABSTRACT

In this paper, we present a sample of cluster galaxies devoted to study the environmental influence on the star formation activity. This sample of galaxies inhabits in clusters showing a rich variety in their characteristics and have been observed by the SDSS-DR6 down to $M_B \sim -18$, and by the Galaxy Evolution Explorer AIS throughout sky regions corresponding to several megaparsecs. We assign the broadband and emission-line fluxes from ultraviolet to far-infrared to each galaxy performing an accurate spectral energy distribution for spectral fitting analysis. The clusters follow the general X-ray luminosity versus velocity dispersion trend of $L_X \propto \sigma_c^{4.4}$. The analysis of the distributions of galaxy density counting up to the 5th nearest neighbor $\Sigma_5$ shows: (1) the virial regions and the cluster outskirts share a common range in the high density part of the distribution. This can be attributed to the presence of massive galaxy structures in the surroundings of virial regions. (2) The virial regions of massive clusters ($\sigma_c > 550$ km s$^{-1}$) present a $\Sigma_5$ distribution statistically distinguishable ($\sim 96\%$) from the corresponding distribution of low-mass clusters ($\sigma_c < 550$ km s$^{-1}$). Both massive and low-mass clusters follow a similar density–radius trend, but the low-mass clusters avoid the high density extreme. We illustrate, with ABELL 1185, the environmental trends of galaxy populations. Maps of sky projected galaxy density show how low-luminosity star-forming galaxies appear distributed along more spread structures than their giant counterparts, whereas low-luminosity passive galaxies avoid the low-density environment. Giant passive and star-forming galaxies share rather similar sky regions with passive galaxies exhibiting more concentrated distributions.

Key words: catalogs -- galaxies: clusters: general -- galaxies: dwarfs -- galaxies: evolution -- galaxies: interactions -- ultraviolet: galaxies

Online-only material: color figures, machine-readable table

1. INTRODUCTION

The clusters of galaxies are excellent laboratories for studying the influence of the environment on galaxies. This influence is formed by environmental processes which are combinations of interactions of galaxies with other components of the universe: galaxies, dark matter, and plasma. The highest peaks of density in the spatial distribution of these components are in the cores of galaxy clusters. The galaxy population in the centers of clusters reaches volume densities of up to $10^3$ bright galaxies per Mpc$^3$ on spatial scales of $\sim 1$ Mpc, and those galaxies have relative velocities of several hundreds of km s$^{-1}$ (Cox 2000). The mass of dark matter halos of clusters is several orders of magnitude greater than the sum of masses of the stellar component of galaxies with mass-to-light ratios that range from 100 to 500 $M_\odot/L_\odot$ (Cox 2000) opposite the mass-to-light ratio for stellar component which covers the range 1–10 $M_\odot/L_\odot$ (Bell et al. 2003). The pressure of the intracluster medium (ICM), which with $n_e \sim 10^{-3}$ cm$^{-3}$ and temperatures from $10^5$ to $10^8$ K, is nearly high enough to act on the gas component of galaxies (Gunn & Gott 1972).

Each of the interactions of galaxies with these components (galaxies, ICM, dark matter halo) has a contribution in the different environmental processes. The interaction of galaxies with the ICM dominates the gas stripping processes, where the interstellar medium of galaxies is stripped via various mechanisms, including viscous and turbulent stripping (Tonizzio & Schindler 2001), thermal evaporation (Cowie & Songaila 1977), and ram pressure stripping (Quilis et al. 2000). The tidal interactions among galaxies dominate the galaxy mergers or strong galaxy–galaxy interactions (Mihos 2004) and the galaxy harassment (Moore et al. 1996, 1998, 1999). The environmental process known as strangulation, starvation, or suffocation is dominated by the tidal interaction with the dark matter halo of the cluster which removes the hot gas halo of the galaxy (Bekki et al. 2002). The environmental processes act on the stellar and gas/dust components of a galaxy modifying its gas content, the star formation level, the structural and dynamical parameters, etc. On the one hand, the intensity of the environmental processes depends on galaxy properties such as the stellar mass or the compactness of stellar component. Also, the environmental influence depends on the environmental conditions and/or the cluster properties as the density of cluster components (galaxies, ICM, dark matter halo), the velocity field of the cluster, etc. Specifically, there is a controversy about the dependence on global cluster properties (e.g., $\sigma_c$) of the star formation activity of cluster galaxy population. Numerous works point out that there is no such correlation (Smail et al. 1998; Andreon & Ettori 1999; Ellingson et al. 2001; Fairley et al. 2002; De Propris et al. 2004; Goto 2005; Wilman et al. 2005; Andreon et al. 2006) while other works claim the presence of a relation between the star formation activity and the global cluster properties (Martínez et al. 2002; Biviano et al. 1997; Zabludoff & Mulchaey 1998; Margoniner et al. 2001).

The cores of galaxy cluster are located around the peaks of densities of these components but the volume density of cluster components converges to the field value toward regions outside the virial regions in distances of some virial radii (Cox 2000; Rines et al. 2003). So, the transition between the cluster centers and the surroundings samples a broad range of environmental properties. The environmental processes act on galaxies with different intensity depending on the galaxy (dynamical or...
stellar) mass or luminosity (see Boselli & Gavazzi 2006, for a review), but in most of the previous works the observed trends of galaxy properties are restricted to giant $L \gtrsim L^*$ galaxies. The UV luminosity has revealed as a good proxy of the recent star formation rate (SFR) because it is a tracer of the more short-lived stars $\tau < 10^8$ yr (Kennicutt 1998) and the UV–optical colors as an excellent classifier between passive evolving galaxies and star-forming galaxies (Chilingarian & Zolotukhin 2012). On the other hand, the optical and near-infrared spectral ranges sample stellar populations with ages that range from $10^9$ to $10^{10}$ years (Kennicutt 1998; Martin et al. 2005). This provides some important insights into the global star formation history of a galaxy, i.e., the stellar mass, the timescale of the star formation history, etc.

Following the former considerations, we will design a sample of clusters nearly nearby enough for their galaxies to be observed around the classical luminosity limit between giant and dwarf galaxies $M_B = -18$ by the DR6 of Sloan Digital Sky Survey (SDSS). We stress that the cluster galaxy population must be observed by different surveys from UV to Far-IR (FIR) in the central regions of each cluster and its surroundings up to several times the size of virial region. This cluster sample allows us to study the environmental behavior of different properties (current star formation, stellar mass, attenuation, etc.) of a galaxy population with a broad luminosity range that inhabits environments as different as the center of galaxy clusters or their surroundings.

The remainder of the paper is organized as follows. In Section 2, we describe the design of the cluster sample. In Section 3, we describe the compilation of broadband and emission line fluxes for the galaxy sample of the cluster sample. In Section 4, we show the compilation of fluxes for the galaxy sample, color–color distributions, and an example of the spectral energy distribution (SED) of a galaxy from the sample. In Section 5, we discussed three different items: the bolometric X-ray luminosity versus cluster velocity dispersion $L_X - \sigma_v$ relation, the local density $\Sigma$ distribution of galaxy population split by their membership to virial regions of low-mass/massive clusters, and a hint for future work and the sky projected density of giant/low-luminosity and passive/star-forming galaxy population in a massive cluster. We summarized our findings in Section 6.

2. CLUSTER SAMPLE SELECTION

One of the purposes of the sample design is embrace a luminosity range for the cluster galaxy sample wide enough to contain the classical limit between giant and dwarf galaxies, $M_B = -18$. This constrains the redshift range of the cluster sample. The cluster sample is observed in a sky area which is delimited by the intersection of observed sky areas of SDSS and Galaxy Evolution Explorer (GALEX) surveys. Both surveys are incomplete (at the moment of sample definition, 2008 March) and have smaller observed sky areas than the other ended surveys, Two Micron All Sky Survey (2MASS) and Infrared Astronomical Satellite (IRAS). In order to sample a broad range of environments, we select galaxy clusters observed by these surveys up to regions several virial radius beyond the virial region. So, we discard those clusters with a poor sky coverage not only in the central regions but also in the outskirts of clusters.

In the following, we describe the process of building the cluster sample. In a first step, we take a compilation of Galaxy Clusters from NED. Thanks to this approach, we take account of all cluster selection criteria in the literature; visual inspection, image-smoothing techniques, X-ray extended sources detection, Red Sequence algorithm, surveys around cD galaxies, etc. This avoids any kind of bias in the cluster selection. We have selected all astrophysical objects with NED Object Type set to GClsr.

We constrain the redshift range to reach down to the absolute magnitude limit of dwarf galaxies. The Main Galaxy Sample of SDSS reaches up to $r'_{\text{MGS}} = 17.77$ (Strauss et al. 2002), while the absolute magnitude limit for a dwarf galaxy starts at $M_B^{\text{Dwarf}} = -18$ (Binggeli et al. 1988; Mateo 1998), so

$$R = r'_{\text{MGS}} - 0.1837(g - r) - 0.0971 \quad (\text{Lupton 2005})$$

$$M_R \equiv M_B^{\text{Dwarf}} - (B - R)$$

$$\mu \equiv R - M_B$$

$$\log z = 0.2\mu - 8.477 + \log h(\text{Local Universe, i.e., } c z \approx HD = 100hD),$$

with $B$, $R$ apparent Johnson magnitudes; $M_B$, $M_R$ absolute Johnson magnitudes; $\mu$ distance modulus; $H \equiv 100h$ with the Hubble’s constant and $z$ the redshift. We assume $h = 0.7$ in this work. Assuming the $(B - R)$ values observed by Mobasher et al. (2003) and the $(g - r)$ values observed by Blanton et al. (2003) for red and blue galaxies, we obtain an upper limit in redshift of

$$\text{Blue galaxies: } (B - R) \approx 0.8, \quad (g - r) \approx 0.2 \Rightarrow z \approx 0.044$$

$$\text{Red galaxies: } (B - R) \approx 2.0, \quad (g - r) \approx 1.0 \Rightarrow z \approx 0.071.$$
In the first step, we select the galaxies inside 2.2 Abell radii from the NED center and within a redshift range defined by \( \Delta z = \pm 0.015 \) from the cluster redshift given by NED. From these galaxies, we estimate the cluster redshift, \( z_c \), and the cluster redshift dispersion \( \sigma_c \) as the median and the median absolute deviation, respectively. If \( \sigma_c \) is higher than 0.0017 \((\approx \sigma_c = 500 \text{ km s}^{-1} \text{ at } z = 0)\), we set \( z_c \) to this value. This step is useful for avoiding too much contamination from surrounding galaxy structures. Then, we computed the radius \( r_{200} \) from \( z_c \) and \( \sigma_c \) using the following equation:

\[
r_{200} = 1.73 \frac{\sigma_c}{1000 \text{ km s}^{-1}} \frac{1}{\sqrt{\Omega_m + \Omega_r (1+z_c)^3}} h^{-1} \text{ Mpc},
\]

which is taken from Finn et al. (2005). First, we recomputed \( z_c \) and then \( \sigma_c \) from those galaxies within \( \pm 3\sigma_c \) from \( z_c \) and nearer to the cluster center than 1.2 \( r_{200} \). This process iterates until it reaches the convergence. After each iteration, every galaxy in the initial sample can reenter the cluster sample whether it meets the constraints on redshift and position or not. If the process does not converge, we discard that cluster. The error of the final \( \sigma_c \) is computed using a bootstrap algorithm that applies to the galaxy sample in each cluster.

In this procedure, there are clusters which reach the convergence and show a final \( z_c \) far away from NED cluster redshift or with \( \sigma_c \gg 1000 \text{ km s}^{-1} \). After a visual check of radial velocity histograms of these structures, we conclude that those galaxy structures are far from being real clusters. In order to discard those structures, we add two constraints to the cluster sample:

\[
|z_c - z_{med}| \leq 0.0033
\]

\[
\sigma_c \leq 1300 \text{ km s}^{-1}.
\]

After applying the procedure from Poggianti et al. (2006) and including this constraint to the former sample, the resulting sample is composed of 86 clusters. At the end of this procedure, we still impose a further condition related to the presence of clusters with more than one NED identifier: NED only classifies two clusters from different catalogs as being the same cluster if their angular separation is less than 2 arcmin (Marion Schmitz–NED team, 2008, private communication). Using this clue, we take the cluster name from the most ancient catalog to identify those clusters with more than one NED identifier.

As a final step, we visually check the GALEX AIS coverage of each cluster up to some Abell radius. We end up with 16 clusters in the redshift range 0.02 < \( z \) < 0.05. Their basic properties are listed in Table 1. Their appearance in the sky and their radial velocity distributions are shown in Figures 1 and 2, respectively. Figure 3 shows the color-composite images of the central regions of clusters retrieved from the SDSS Navigate Tool http://skyserver.sdss.org/public/en/tools/chart/navi.aspx.

Taking a look to the sky distribution of clusters from the sample in Figure 1, one can see the wide variety of the cluster sample in cluster richness and spatial structure and in some cases, the presence of galaxy structures around the virial regions of clusters. The richness ranges from the poor cluster WBL 245 or WBL 234 with only a few galaxies in their central regions, to the massive cluster ABELL 2199, which is assembled in the supercluster ABELL 2197–ABELL 2199–B2 1621+38:[MLO2002] or the cluster ABELL 1185, with clear evidence of galaxy structures as filaments. There are apparently “isolated” clusters as UGCI 271 or UGCI 148 NED01 opposite the example of WBL 514 with a close “twin” cluster, WBL 518 (Beers et al. 1995).

### Table 1

Main Properties of the Cluster Sample

| ID NED       | \( \Delta J(2000) \) (deg) | \( \Delta \beta(2000) \) (deg) | \( z_{med} \) | \( \sigma_c \) \((\text{km s}^{-1})\) | \( r_{200} \) \((\text{Mpc})\) | N\(200\) | N\(int\) | \( \theta_\text{int} \) (deg) | \( \theta_\text{tot} \) (deg) | \( \log(L_X) \) |
|--------------|------------------|------------------|-------------|-----------------|-----------------|------|-------|----------------|-----------------|-------------|
| UGCI 141     | 138.499          | 30.2094          | 0.0228      | 501.8           | 1.21            | 48   | 413   | 4.159          | 42.12           |             |
| WBL 245      | 140.120          | 20.5119          | 0.0255      | 86.7            | 0.20            | 2    | 88    | 3.720          | ...             |             |
| UGCI 148 NED01| 140.366          | 20.3129          | 0.0263      | 316.7           | 0.76            | 21   | 21    | 3.606          | ...             |             |
| ABELL 2199   | 247.154          | 39.5244          | 0.0303      | 756.2           | 1.83            | 313  | 1104  | 3.125          | 44.85           |             |
| WBL 213      | 139.283          | 20.0403          | 0.0290      | 537.1           | 1.29            | 62   | 548   | 3.266 \(\leq 41.9\) |             |             |
| WBL 514(*)   | 218.504          | 3.78111          | 0.0291      | 633.7           | 1.52            | 88   | 580   | 3.257          | 43.18           |             |
| WBL 210      | 139.025          | 17.7242          | 0.0287      | 433.3           | 1.06            | 56   | 402   | 3.298          | 43.22           |             |
| WBL 234      | 145.602          | 4.27111          | 0.0291      | 243.6           | 0.58            | 6    | 87    | 3.262          | ...             |             |
| WBL 205      | 137.387          | 20.4464          | 0.0288      | 679.8           | 1.60            | 37   | 527   | 3.289          | ...             |             |
| UGCI 393     | 244.500          | 35.1000          | 0.0314      | 637.9           | 1.52            | 121  | 529   | 3.016          | 43.60           |             |
| UGCI 391     | 243.352          | 37.1575          | 0.0330      | 407.0           | 0.97            | 8    | 637   | 2.874          | ...             |             |
| B2 1621+38:[MLO2002] | 245.583 | 37.9611          | 0.0311      | 607.3           | 1.46            | 95   | 1053  | 3.046          | 43.19           |             |
| UGCI 271     | 188.546          | 47.9811          | 0.0305      | 323.2           | 0.72            | 23   | 181   | 3.104          | ...             |             |
| ABELL 1185   | 167.699          | 28.6783          | 0.0328      | 789.3           | 1.90            | 228  | 754   | 2.894          | 43.58           |             |
| ABELL 1213   | 169.121          | 29.2603          | 0.0469      | 565.7           | 1.35            | 98   | 305   | 2.021          | 43.77           |             |
| UGCI 123 NED01| 127.322          | 30.4828          | 0.0499      | 849.0           | 2.00            | 113  | 260   | 1.900          | 44.32           |             |

Notes. (1) NED identifier; (2) and (3) celestial coordinates of cluster center from the NED Web site; (4) cluster average redshift; (5) cluster velocity dispersion; (6) radius 200; (7) no. of galaxies inside virial region with SDSS redshift; (8) no. of galaxies associated with each cluster selected by criteria exposèd in Section 3.1; (9) half-size of sky square region retrieved for each cluster, computed assuming the Local Universe approximation \( c = H_0 \); (10) bolometric X-ray luminosity from Mahdavi & Geller (2001) except for WBL 213 (Mahdavi et al. 2000). (*) The historical criterion is not applied. In the case of WBL 514, we have selected WBL 514 instead of MKW07 because this object is split into two clusters by a late reference (Struble & Rood 1991). The source of the data is specified. Otherwise, the data are results from this work. The cluster compilation was carried out from NED updated on 2008 March 28.
far-infrared around 100 μm for the cluster galaxy sample. In the last few decades, this task has become possible thanks to several sky surveys covering large areas of the sky from UV to FIR. We present a brief summary of the main galaxy surveys from which we retrieve spectrophotometric fluxes for the cluster galaxy sample and summarize the main figures of each survey in Table 2.

1. Galaxy Evolution Explorer (GALEX; Martin et al. 2005) was launched to, among other surveys, cover all sky at different depth and areas in two UV filters, the far-ultraviolet (FUV) band (1350–1750 Å) and the near-ultraviolet (NUV) band (1750–2750 Å). The AIS plans to survey the entire sky down to a sensitivity of $m_{AB} \approx 20.5$, comparable with the sensitivity of the SDSS Main Galaxy Sample, $r'_{MGS} = 17.77$ (Strauss et al. 2002).

2. The SDSS Project (6th Data Release in Adelman-McCarthy et al. 2008) retrieved spectra from, among other
astronomical objects, all galaxies with $r' < 17.77$ from the SDSS Imaging Catalog. The SDSS photometric system (Fukugita et al. 1996) covers from 3000 to 11000 Å in five broadband filters ($u'$, $g'$, $r'$, $i'$, and $z'$).

3. The 2MASS (Cutri et al. 2001) has uniformly scanned the majority of the sky in three near-infrared (NIR) bands, $J$ (1.25 μm), $H$ (1.65 μm), and $K_s$ (2.17 μm).

4. The IRAS (Neugebauer et al. 1984) was a project to perform an unbiased, sensitive all sky survey at 12, 25, 60, and 100 μm, down to a limiting flux of 0.2 Jy at 60 μm. This mission produced two main catalogs: the Point Source Catalog (PSC; Joint Iras Science 1994) and the Faint Source Catalog (FSC; Moshir et al. 1993).

3.1. SDSS Data

The cross-correlation of celestial coordinates from different catalogs has been accomplished using the SDSS celestial coordinates as the fiducial coordinates. For each cluster, we retrieve all galaxies from the DR6 of SDSS with the following criteria:
Figure 2. Radial velocity histograms for the cluster sample. The black histograms represent the galaxy sample inside a projected radius \( R_P < 3r_{200} \) and the red histograms correspond to those galaxies inside a projected radius set to one virial radius \( R_P = r_{200} \). The range of abscissa in each panel is set to \( \pm 5 \sigma_c \) of each cluster.

(A color version of this figure is available in the online journal.)

1. \( R_P \leq 7.1 \) Mpc
2. \( z_c - 5\sigma_c \leq z \leq z_c + 5\sigma_c \)
3. \( z \geq 10^{-3} \) (in order to avoid stars in the lowest redshift clusters).

We retrieve photometric and spectroscopic data from the SDSS database for this galaxy sample. The photometric fluxes come from the five broadband filters of SDSS. We select the “composite flux” magnitude (Abazajian et al. 2004) as the suitable way to retrieve the total flux from each galaxy with the minimum uncertainty in color. We summed the error reported by the SDSS photometric pipeline (photo; Lupton et al. 2001) and the calibration errors reported in the DR6 of SDSS (Adelman-McCarthy et al. 2008), the standard deviation (based on the interquartile range) of distribution of the difference \( r_{\text{composite}} - r_{\text{petrosian}} \) to account uncertainties in color which are not present in the standard accurate-color photometry (i.e., petrosian magnitude; Abazajian et al. 2004).

We include spectroscopic data regarding to spectroscopic redshift and the fluxes for the four emission lines of the BPT diagram (Baldwin et al. 1981); \([\text{O} III] \) (\( \lambda = 5007 \) Å), \( \text{H}\beta \)
Figure 2. (Continued)

Moustakas et al. (2006) claim that the extinction-corrected Hα luminosity is a reliable SFR tracer, even in highly obscured star-forming galaxies. We derive galaxy SFRs from the extinction-corrected Hα luminosity. The extinction correction is applied using the Balmer decrement method and the Cardelli et al. (1989) extinction law with $RV = 3.1$. We take a H$I$ recombination line ratio in the theoretical case B nebulae at $T = 10^4$ K as $Hα/Hβ = 2.87$. We apply the scaling law between SFR and Hα luminosity proposed by Kennicutt (1998).

SDSS project has a pair of fiber-fed double spectrographs with 3 arcsec of fiber diameter on sky. This produces a loss of light from external parts of the largest galaxies. In order to reduce systematic and random errors from this “aperture effect” in SFR estimation, Kewley et al. (2005) recommend selecting galaxy samples with the fiber capturing more than the 20% of the galaxy $B_{445\,\text{nm}}$ light. We assume an SDSS spectrum as representative of a galaxy when the fiber contains at least one-fifth of the total g-band flux of the galaxy. So, we select these galaxies with
Figure 3. SDSS color-composite images of the central regions of clusters. The horizontal line in the upper left corner indicates the pixel scale of the image.

(A color version of this figure is available in the online journal.)
Figure 3. (Continued)


Table 2

Main Figures of Galaxy Surveys

| SURVEY       | Band | \(\lambda_c\) (\(\mu\)m) | \(\Delta\lambda\) (\(\mu\)m) | \(m_{\text{lim}}\) (AB mag) |
|--------------|------|--------------------------|-------------------------------|-----------------------------|
| GALEX\(^a\) | FUV  | 0.1550                   | 0.400                         | 20.5                        |
|              | NUV  | 0.2250                   | 1.000                         | 20.5                        |
| SDSS\(^b\)  | u'   | 0.3551                   | 0.599                         | 22.0                        |
|              | g'   | 0.4686                   | 1.379                         | 22.2                        |
|              | r'   | 0.6165                   | 1.382                         | 22.2                        |
|              | i'   | 0.7481                   | 1.535                         | 21.3                        |
|              | z'   | 0.8931                   | 1.370                         | 20.5                        |
| 2MASS\(^c\) | J    | 1.25                     | 1.620                         | 16.39                       |
|              | H    | 1.65                     | 2.510                         | 16.37                       |
|              | Ks   | 2.17                     | 2.620                         | 16.34                       |
| IRAS(PSC+FSC)\(^d\) | 12 \(\mu\)m | 12 | 7.00 | 10.64 |
|              | 25 \(\mu\)m | 25 | 11.15 | 10.64 |
|              | 60 \(\mu\)m | 60 | 32.5 | 10.64 |
|              | 100 \(\mu\)m | 100 | 32.5 | 8.9 |

Notes. (1) Survey; (2) spectral band; (3) central wavelength; (4) spectral bandwidth; (5) completeness limit. \(^a\)Martín et al. (2005); \(^b\)Adelman-McCarthy et al. (2008); \(^c\)Finlator et al. (2000); \(^d\)Joint Iras Science (1994) + Moshir et al. (1993). Some galaxies in the FSC have upper limits with fluxes greater than these nominal values.

\[
(g_{\text{fiber}} - g_{\text{model}}) \leq -2.5 \log_{10}(0.2),
\]

\(g_{\text{fiber}}\) is the \(g\)-band magnitude measured inside an aperture similar to those produced by the SDSS fiber and \(g_{\text{model}}\) is the \(g\)-band “model” magnitude. In this case, we scale \(H\) fiber flux to \(H\) total flux using \(10^{\Delta g_{\text{model}} - \Delta g_{\text{fiber}}}\) as scaling factor. Otherwise, we set \(H\) fiber flux (without any scaling) as the lower limit for the \(H\) total flux of these galaxies.

3.2. SDSS–GALEX Cross-correlation

Following the criterion proposed by Obrić et al. (2006), we choose a matching radius of 6 arcsec between the SDSS and GALEX AIS celestial coordinates. We accomplish the source matching using the GALEX application GalexView.\(^4\) In the case there is not a GALEX source in the matching circle, we do not assign a UV flux to SDSS source. The fraction of SDSS sources without GALEX detection is less than 20%. There are two options for the case of a non-matched source or this sky region is not observed by GALEX AIS or the UV flux for the SDSS source is under GALEX AIS detection limit. The first case does not introduce a biased selection of galaxies, i.e., there is no correlation between the celestial coordinates and the galaxy properties. In the second case, we have a completeness limit for the SDSS Main Galaxy Sample of \(r_{\text{50\%}} < 17.77\) and the GALEX AIS reaches down to NUVlim \(\sim 22\) for Galactic extinction-corrected magnitudes, while the UV–optical color separation between blue and red galaxies is NUV \(- r \sim 4\). So, this case only affects red galaxies in the lowest flux bin \(r' \gtrsim 16\).

We choose the elliptical aperture photometry (\(\text{MAG\_AUTO}\) option in SExtractor code; Bertin & Arnouts 1996) for GALEX sources in order to have the complete UV flux for each source. These magnitudes are corrected from Galactic extinction using the excess color \(E(B-V)\) reported in GALEX tables for each UV source and assuming the Cardelli extinction law (Cardelli et al. 1989).

3.3. SDSS–2MASS Cross-correlation

The 2MASS project has enough image quality (FWHM \(\sim 2.5–2.7\) arcsec; Cutri et al. 2001) to discriminate point-like sources (i.e., stars) from the extended ones (i.e., galaxies); the angular distance at \(z = 0.05\) is 0.977 kpc arcsec\(^{-1}\). So, we only cross-correlate the galaxy sample with the 2MASS All-Sky Extended Source Catalog and not the 2MASS All-Sky PSC. We follow Blanton et al. (2005) and set the matching radius to 3 arcsec.

The NIR magnitudes for each SDSS source without 2MASS counterpart are fixed, as a lower limiting flux, to the completeness limit in each 2MASS band (Finlator et al. 2000). In this case, we set the error for the lower limit to a nominal value of \(\Delta m = 1\) mag, which is the magnitude interval along the galaxy counts in the NIR that decrease from the 100% completeness down to zero.\(^5\) The matching rates vary from cluster to cluster and are around 40%–60%.

We choose the photometry named total magnitude for the three NIR bands which is obtained from the integral between the lowest elliptical radius with a surface brightness of \(\mu = 20\) mag arcsec\(^{-2}\) (this corresponds to \(\sim\)1\(\sigma\) of the sky background; Cutri et al. 2001) and a elliptical Sérsic profile (Sérsic 1963) fitted to the surface brightness profile of the galaxy (Jarrett et al. 2000). We apply the magnitude conversion from Vega system to AB system from Finlator et al. (2000).

3.4. SDSS–IRAS Cross-correlation

Owing to the low angular resolution of IRAS telescope,\(^6\) the galaxies resemble IRAS point-like sources. So, we crossmatch the galaxy sample with a joint catalog of PSCz+FSC; Point Source Catalog (Joint Iras Science 1994) ⊕ Faint Source Catalog (Moshir et al. 1993). The FSC is \(\sim 2.5\) times deeper in limiting flux than the PSCz catalog and the approximated flux frontier between these two catalogs is around 0.4 Jy. We set the matching radius to \(r = 40\) arcsec, the value proposed by Blanton et al. (2005). Anyway, the matching rate is quite low \(\sim 1\%–5\%\). The upper limit in IRAS flux for galaxies without IRAS counterpart is set to the values proposed for the FSC at each IRAS band (Moshir et al. 1993). We set the upper limit error to the nominal (absolute+relative) error reported in PSCz catalog: 11% \(\pm\) 0.06 Jy.

4. THE SPECTROPHOTOMETRIC CATALOG

The format of the spectrophotometric catalog is presented in Table 3. It contains 53 columns that are described below, including the relevant observational parameters, spectrophotometric fluxes from UV to FIR, and SFR estimates.\(^7\)

Column 1. ID: number associated with the position of the galaxy inside the cluster galaxy sample as an identifier.

Columns 2 and 3. ObjID and specObjID: SDSS Imaging Catalog and Main Galaxy Sample identifier of the galaxy.

Columns 4 and 5. R.A. and decl.: SDSS right ascension and declination (J2000) in degrees.

Columns 6 and 7. \(z\) and \(\epsilon_z\): SDSS spectroscopic redshift and its uncertainty.

\(^a\)http://galex.stsci.edu/GalexView/
\(^b\)http://galex.stsci.edu/GalexView/
\(^c\)http://galex.stsci.edu/GalexView/
\(^d\)http://galex.stsci.edu/GalexView/
\(^e\)http://www.ipac.caltech.edu/2mass/releases/allsky/doc/sec2_3d3.html
\(^f\)http://irsa.ipac.caltech.edu/IRASdocs/exp_sup/ch2/C3.html
\(^g\)The catalog will be presented in its entirety in the online version of the paper.
Table 3
Spectrophotometric Catalog of Cluster Galaxy Sample

| ID   | ObjID          | SpecObjID  | R.A.  | Decl. | z   | σz  | AB_FUV | σ_FUV | i_FUV | AB_NUV | σ_NUV | i_NUV | AB_BFUV | σ_BFUV | i_BFUV | AB_BFUV | σ_BFUV | i_BFUV | AB_BFUV | σ_BFUV | i_BFUV |
|------|----------------|------------|-------|-------|-----|------|--------|-------|-------|--------|-------|-------|---------|--------|--------|---------|--------|--------|---------|--------|--------|
| 1    | 58773523956537792 | 357982217034508160 | 134.655685 | 31.482407 | 0.02662 | 0.00009 | 19.09200 | 0.13216 | 1 | 18.683599 | 0.082258 | 1 |
| 2    | 587735240649381760 | 357982219328815104 | 134.670593 | 32.448460 | 0.02233 | 0.00009 | 19.09200 | 0.13216 | 1 | 18.683599 | 0.082258 | 1 |
| 3    | 587735250436599660 | 358263757475938304 | 135.079346 | 32.780834 | 0.02233 | 0.00009 | 19.09200 | 0.13216 | 1 | 18.683599 | 0.082258 | 1 |
| 4    | 587735260308704944 | 358263758667120640 | 136.960205 | 33.468132 | 0.02638 | 0.00017 | 21.17820 | 0.279031 | 1 | 19.302299 | 0.095046 | 1 |

In sets of three elements, the following columns show the AB magnitude of galaxy, its uncertainty, and the detection identifier 

8 Code for detection identifiers: 1 = Source detected on this band, 0 = Source undetected on this band (lower limit in flux), -1 = Source not observed on this band, and -2 = Lower limit in flux.

Columns 8, 9, and 10. AB_FUV, σ_FUV, and i_FUV: the GALEX FUV band.
Columns 11, 12, and 13. AB_NUV, σ_NUV, and i_NUV: the GALEX NUV band.
Columns 14, 15, and 16. AB_g, σ_g, and i_g: the SDSS u' band.
Columns 17, 18, and 19. AB_g, σ_g, and i_g: the SDSS g' band.

NUV band.

The Astrophysical Journal Supplement Series, 199:22 (18pp), 2012 March
Hernández-Fernández, Iglesias-Páramo, & Vilchez

This table is available in its entirety in a machine-readable form in the online journal. A portion is shown here for guidance regarding its form and content.
The galaxy sample traces the only galaxies with detection in the three corresponding UV–optical–NIR color–color diagrams; in each panel we show a galaxy. The cluster identifiers are codified in the following way: (A B) for the parent cluster of the sample. Figure 4 shows how the galaxy sample traces the diversity of cluster properties. Special care has been exercised to minimize cluster selection bias and to include a large diversity of cluster properties. Special care has been exercised to

\[ \chi^2 = 1.07 \]

from Hα luminosity which covers 3 dex in wavelength and 1 dex in luminosity spectral density. Figure 5 highlights the importance of a consistent photometry capturing the total flux in each band along the SED in order to apply an accurate spectral fitting analysis. Figure 5 also illustrates the comparison of this SED with its best-fitted spectral template from a synthetic spectral library in Hernández-Fernández (2011).

5. DISCUSSION

In this work, we build up an extended catalog of galaxies belonging to a sample of nearby clusters carefully selected to minimize cluster selection bias and to include a large diversity of cluster properties. Special care has been exercised to
follow an appropriate methodology producing a self-consistent spectrophotometry along the SED. In this section, we discuss the general properties of the selected clusters, together with the spectral characterization of their galaxies and paying especial attention to the environmental trends of the sample.

5.1. X-Ray Luminosity versus Velocity Dispersion

In Figure 6, we plot bolometric X-ray luminosity versus cluster velocity dispersion, the $L_X$--$\sigma_c$ relation, for the cluster sample. The velocity dispersion and the associated errors are computed assuming the procedure proposed by Poggianti et al. (2006). The bolometric X-ray luminosity values are taken from Mahdavi et al. (2000) and Mahdavi & Geller (2001), assigning an uncertainty of 30% to the X-ray luminosity in the same way as Mahdavi & Geller (2001). The $L_X$--$\sigma_c$ relation for the galaxy clusters with associated X-ray detection (nine clusters) or an associated upper X-ray flux limit (WBL 213) follows in a consistent way the $L_X \propto \sigma_c^{1.4}$ relation found by Mahdavi & Geller (2001) for a sample of 280 galaxy clusters. For some clusters of the sample, we did not find an associated X-ray source in Mahdavi & Geller (2001) catalog neither one NED object with X-ray associated flux (GGroups, GClusters or Xray source) clearly associated with these clusters. Also, we know there is no sources with X-ray bolometric luminosities under $10^{41}$ erg s$^{-1}$ in Mahdavi & Geller (2001) catalog. Assuming these clusters are around or under this X-ray luminosity (with the typical uncertainties for these X-ray luminosities) this group would show a locus consistent with $L_X \propto \sigma_c^{1.4}$ trend, except for the cluster WBL 205. In this cluster, its $\sigma_c$ is overestimated because WBL 205 is clearly formed by two dynamical substructures (see Figure 2).

5.2. Distribution and Radial Trend of the Local Galaxy Density $\Sigma_5$

In Figure 7, we plot the distribution of local galaxy density of the cluster galaxy sample. We choose $\Sigma_5$ as local density estima-

![Figure 6](image-url)  
**Figure 6.** $L_X$--$\sigma_c$. Bolometric X-ray luminosity vs. cluster velocity dispersion. Blue data points indicate X-ray detections and the red data point with $L_X \sim 10^{43}$ erg s$^{-1}$ indicates a confident upper limit in X-ray luminosity. Red data points set to X-ray luminosities $\sim 10^{44}$ erg s$^{-1}$ are associated with undetected X-ray sources. These data points are slightly displaced from $L_X = 10^{41}$ erg s$^{-1}$ for the sake of clarity. The dashed lines represent the $L_X$--$\sigma_c$ relation from Mahdavi & Geller (2001). The cluster identifiers in the plot are codified in the following way: A: ABELL; B2: B2 1621+38; MLO2002 CLUSTER; N: NED; U: UGCI; W: WBL.

(A color version of this figure is available in the online journal.)

![Figure 7](image-url)  
**Figure 7.** $\Sigma_5$ distribution. Reddish/bluish histograms correspond to galaxies inside/outside virial regions. The top panel shows low-mass clusters $\Sigma_5$ distribution and the bottom panel, massive clusters $\Sigma_5$ distribution. Vertical dashed lines show the mean value of $\Sigma_5$ distribution in each case.

(A color version of this figure is available in the online journal.)

...tor following Balogh et al. (2004); this density is computed for each galaxy inside a circle containing up to the fifth neighboring galaxies more luminous than $M_r = -20.6$ with radial velocities not farther than 1000 km s$^{-1}$ from the radial velocity of each galaxy:

$$\Sigma_5 = \frac{5}{4\pi r_5^2},$$

with $r_5$ the distance to the fifth neighboring galaxy more luminous than $M_r = -20.6$ within $\pm 1000$ km s$^{-1}$ in radial velocity. We reject from $\Sigma_5$ distributions galaxies with “edge effects,” those galaxies in which some of their fifth first neighbors are placed far from the radial limits of galaxy sample (7 Mpc) or with a radial velocity out of the limits given by $\pm 5\sigma_c$ around the cluster redshift. We consider four galaxy subsamples in two intervals of velocity dispersion of the parent cluster ($\sigma_c < 550$ km s$^{-1}$—low-mass clusters and $\sigma_c > 550$ km s$^{-1}$—massive clusters) and segregated by their membership to virial regions. The threshold for the cluster velocity dispersion $\sigma_c = 550$ km s$^{-1}$ between the low-mass and the massive clusters approximately matches a gravitational mass of $2 \times 10^{14} M_\odot$ (Cox 2000), a similar value to the characteristic mass of the distribution of cluster mass (Henry & Arnaud 1991).

...
Also, Poggianti et al. (2006) choose a similar value for $\sigma$ as a boundary between two distinct cluster environments with regard to their star formation activity: the massive clusters (those with a high $\sigma$) are extremely hostile environments for star formation activity. They found a different trend of the $[O \text{ II}]$ emission-line fraction with the $\sigma$ in these two cluster environments. The membership to the virial regions is assigned to galaxies inside a projected radius of $r_{200}$ of each cluster and under the general caustic profile in a phase diagram obtained by Rines et al. (2003) for a sample of clusters in the Local Universe.

In a first look at Figure 7, the $\Sigma_5$ ranges from $\sim 10^{-2}$ to $10^2$, a more broad range than the range of $\Sigma_5$ distribution shown by Balogh et al. (2004) for two galaxy samples from SDSS DR1 (Sloan Digital Sky Survey Data Release I; Abazajian et al. 2003) and the $\Sigma_5$ distribution of 2dFGRS (Two degrees Field Galaxy Redshift Survey; Colless et al. 2001) that range from $\sim 3 \times 10^{-2}$ to $\sim 30$. In the higher density side, this difference comes from the lower statistics of this two samples ($\sim 186,240$ galaxies for SDSS DR1 and $\sim 220,000$ for 2dFGRS) versus the SDSS DR6 with $\sim 790,220$ galaxies, i.e., this release contains a higher number of galaxies from the highest density regions, the clusters.

The $\Sigma_5$ distribution of virial regions occupies the range $-1 \lesssim \log \Sigma_5 \lesssim 1.2$ in both cases, massive clusters and low-mass clusters. Although the high-density tail of massive clusters ($\log \Sigma_5 > 1.2$) is absent in the low-mass clusters. In addition, the mean of $\Sigma_5$ for massive clusters ($\log \Sigma_5 \approx 0.6$) is $\approx 0.2$ dex higher than the mean of $\Sigma_5$ for low-mass clusters. We apply a Kolmogorov–Smirnov test to the $\Sigma_5$ distributions of virial regions from the low-mass clusters and the massive clusters. They have a probability of $\sim 4\%$ to come from the same parent population, so they are statistically distinguishable.

The $\Sigma_5$ distribution of galaxies from the outskirts presents a common range ($-2 \lesssim \log \Sigma_5 \lesssim 1.3$). Further, two differences are noticed: (1) the presence of a high density tail ($\log \Sigma_5 \gtrsim 1.3$) in massive clusters and (2) the mean of $\Sigma_5$ in the outskirts of massive clusters ($\log \Sigma_5 \approx -0.3$) is $\approx 0.35$ dex higher than the corresponding mean for the low-mass clusters.

The difference between the mean of $\Sigma_5$ for galaxies in virial regions and galaxies from the outskirts is more than 1 dex for the low-mass clusters versus the difference for massive clusters which is $\approx 0.9$ dex. The overlapping in the high density side of $\Sigma_5$ distributions between virial regions and the outskirts can be explained in the following way. The sample is designed following a set of observational constraints described in Section 2, but the galaxy substructures around the virial region of selected clusters in the sample may not fulfill those constraints. So, there may be galaxy structures in the outskirts of virial regions as massive as their parent cluster, the way one would expect from the similarity of the high density tails between virial regions and outskirts. Anyway, there is a $\Sigma_5$ interval below $\log \Sigma_5 \approx -1$ where the galaxy subsample from the outskirts prevails over the galaxies from virial regions. Also, the absence of the highest density tail in the low-mass clusters is that clear evidence of the local density that reaches its highest value in the more massive galaxy structures, the richest clusters.

In Figure 8, one can see a broad trend for the $\Sigma_5-r_P$ relation ($r_P \equiv R_P/1000$), with the highest densities near to cluster centers at the top of a correlation in the virial region and the lowest densities far from the virial regions in the same way as found by Rines et al. (2005). We find that the $\Sigma_5-r_P$ relation is biased in $\sim 0.5$ dex toward lower densities considering the $\Sigma_5-r_P$ relation obtained by Rines et al. (2005). This bias would come from a deeper luminosity cut for neighboring galaxies which is set to $M_K = -22.7$, enlarging the sample of neighboring galaxies devoted to compute the local density. The density–radius trend shows a more broad relation outside the virial region than the trend for the virial region. This came from the presence of galaxy structures which have peaks of density similar to those in the center of virial regions (e.g., ABELL 2197 or B2 1621+38; MLO2002). The massive clusters show galaxy structures with higher densities in the outskirts of virial regions than the low-mass clusters. Both the massive and low-mass clusters follow a similar trend inside the virial region, but the low-mass clusters reach only up to $\log \Sigma_5 \sim 1.2$ avoiding the highest density tail while the massive clusters reach up to $\log \Sigma_5 \sim 2$. In the outskirts, the major concentration of galaxies in the lower side of the relation traces a common trend for both massive and low-mass clusters.

In Figure 8, we plot a King profile (King 1966) fit by eye to the major concentration of galaxy points along the $\Sigma_5-r_P$ relation:

$$\log \Sigma = \log \Sigma^0 - \beta \log \left[1 + \left(\frac{r_p}{r_c}\right)^2\right]$$

with

$$\Sigma^0 = 2, \beta = 0.75, r_c = 0.05. \quad (3)$$

The King profile was initially applied to the projected galaxy density of Coma cluster by King (1972). The fit from Equation (3) in the $\Sigma_5-r_P$ relation seems to reconcile the narrow relation inside the virial region with the concentration in the lower side of the relation for the surroundings. Both the massive and low-mass clusters seem to follow the same relation along the clustercentric radius, with the massive clusters occupying the top of the density–radius fit.

5.3. Galaxy Projected Distribution

In this section, we stress the relevance of a detailed mapping of the sky distribution of different galaxy populations as a tool for the study of environmental trends of galaxy properties. Such study is illustrated here for ABELL 1185, a massive cluster of our sample. A similar analysis extended to the complete cluster sample is out of the scope of this paper and will be presented elsewhere (Hernández-Fernández et al. 2011b). We segregate galaxy populations according to their luminosity between giant galaxies $M_r < -19.5$ and low-luminosity galaxies $-19.5 < M_r < -18$, and also to their spectral type between passive galaxies and star-forming galaxies. In order to differentiate passive galaxies from star-forming galaxies, we take advantage of the (NUV–r) versus ($u-r$) color–color diagram. We assume that a galaxy is a passive galaxy whether its colors fulfill the following prescription:

$$\begin{align*}
\text{NUV} - r &> 4.9, \quad \text{for } u - r < 2.175 \\
\text{NUV} - r &> -(2(u - r) + 9.25), \quad \text{for } u - r > 2.175 \\
\text{u} - r &> 2.22, \quad \text{whether there is no GALEX counterpart.}
\end{align*}$$

As can be seen in Figure 9, this selection seems more accurate to differentiate star-forming galaxies from passive galaxies than the $u-r$ color cut proposed by Strateva et al. (2001). The broken line traces the minimum in the density of data points of (NUV–r) versus ($u-r$) diagram between the maximum of density regarding the “red sequence” and the more extended maximum tracing the “blue cloud.” The left side of the frontier tries to include in the passive galaxy side the locus of evolved
“E+A” galaxies in a UV–optical diagram (Kaviraj et al. 2007). In the case where there is no UV data for a galaxy, we apply the Strateva’s $u - r$ cut.

In a forthcoming paper (Hernández-Fernández et al. 2011a), we take advantage of this UV–optical color frontier in order to make up a sample of star-forming galaxies in clusters. We analyze the spatial variation of distributions of spectral properties for this sample of star-forming galaxies. We find statistically significant differences, applying a Kolmogorov–Smirnov test, in those distributions throughout different environments, i.e., virial regions, infall regions, and field environment.

Figures 10 and 11 show the sky distribution in ABELL 1185 of giant galaxies $M_r < −19.5$ and low-luminosity galaxies $−19.5 < M_r < −18$, respectively. Both figures also show the sky distribution of star-forming and passive galaxies.

In Figure 10, it can be seen that the main concentration of giant galaxies from the virial region of ABELL 1185 around R.A. $\sim 167.75$, decl. $\sim 28.5$ is framed by the dashed circle. There are evident galaxy agglomerations around the virial region of ABELL 1185 with less structural entity than ABELL 1185, except for the group of galaxies in the south side around R.A. $\sim 167.8$, Decl. $\sim 27.5$. We check the redshift distribution of galaxies around this location and find an evident dynamical structure around $z = 0.034$. This aggregate of galaxies, showing a strikingly high fraction of passive giant galaxies, can be linked with the “bare” massive-cluster cores identified by Poggianti et al. (2006). Poggianti et al. (2006) propose, as a hypothesis, that systems close to more massive structures, thus embedded in a massive superstructure, have a different galactic content than completely isolated galaxy systems of similar mass. They suggest that these objects lived in regions that were very dense at high redshift but failed to acquire star-forming galaxies at later times, possibly due to the characteristics of their surrounding supercluster environment. On the other hand, the maxima in the sky distribution of passive giant galaxies trace the central position of the main structures as ABELL 1185 and the “bare core” at the south side, while star-forming galaxies occupy these regions with a more spread distribution, following the general trend for clustering depending on spectral type found in astrophysical observations and simulations (e.g., Madgwick et al. 2003; Springel et al. 2005).

We plot the sky distribution of low-luminosity $−19.5 < M_r < −18$ galaxies in Figure 11. These galaxies show a more continuous sky distribution around the central region of ABELL 1185 connecting this region with the structures in the south, east, and west side of the cluster. This is in good agreement with a less clustered low-luminosity population as suggested in the literature (e.g., Norberg et al. 2002; Springel et al. 2005). The star-forming galaxies occupy both the densest regions and less dense regions, but the passive galaxies seem to preferably
Figure 10. Sky projected density of giant $M_r < -19.5$ galaxies around ABELL 1185. The gray intensity map corresponds to the sky projected density of giant galaxies (both passive and star-forming galaxies). Orange/magenta points represent sky position and red/blue contours represent isodensity lines of the sky projected density of giant galaxies classified as passive/star-forming galaxies. The lowest density contour corresponds to a $\Sigma = 3\, \text{gal Mpc}^{-2}$ and the contours are equispaced in $\Delta \Sigma = 3\, \text{gal Mpc}^{-2}$ up to the maximum in density. The circle in the lower-left corner shows the FWHM size of Gaussian kernel to compute the density map.

(A color version of this figure is available in the online journal.)

Figure 11. Sky projected density of low-luminosity $-19.5 < M_r < -18$ galaxies around ABELL 1185. Color code, isodensity lines, and the rest of elements of the figure are the same as in Figure 10.

(A color version of this figure is available in the online journal.)
inhabit the central region of the structures, avoiding the field environment in the same way as observed by Haines et al. (2006).

6. SUMMARY

We expose the main results and conclusions of this paper in this itemized summary.

1. We compile a sample of galaxies which inhabits in clusters showing a broad range of cluster properties ($\sigma_c$, morphology, etc). This galaxy sample is observed down to the luminosity frontier between giant and dwarf galaxies by the Main Galaxy Sample of SDSS and other galaxy surveys from UV to FIR. We build a spectrophotometric catalog for this cluster galaxy sample with a detailed photometry for each galaxy in order to be accurate for spectral template fitting.

2. The clusters from the sample with X-ray detections or confident upper limits are consistent with the X-ray luminosity versus cluster velocity dispersion $L_X \propto \sigma_c^{1.4}$ trend found by Mahdavi & Geller (2001). The clusters with no X-ray fluxes in the literature can be reconciled with the $L_X-\sigma_c$ trend assuming an upper limit in X-ray luminosity of $10^{41}$ erg s$^{-1}$, except for the case of WBL 205, a cluster with clear evidence of the presence of dynamical substructures.

3. The galaxy density $\Sigma_5$ distribution of virial regions is biased to higher densities with respect to the $\Sigma_5$ distribution of the outskirts. The $\Sigma_5$ distribution of massive clusters (virial regions and the outskirts) shows similar ranges than the low-mass clusters, but they have higher averages of $\Sigma_5$ than the low-mass clusters and present a highest density tail which is missing in the low-mass clusters.

4. The $\Sigma_5-\sigma_p$ relation shows a more broad trend outside the virial region than the trend for the virial region, due to the presence of density peaks. Both the massive and low-mass clusters follow a similar trend inside the virial region, but the low-mass clusters avoid the highest density tail. This relation is well fitted by a King profile along the clustercentric radius, for both the massive and the low mass clusters.

5. ABELL 1185 shows clear evidences of galaxy structures around the virial region. In this cluster, low-luminosity star-forming galaxies are distributed along more spread structures than their giant counterparts, whereas low-luminosity passive galaxies avoid the low-density environment. Giant passive and star-forming galaxies share rather similar sky regions with passive galaxies exhibiting more cuspy distributions.

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