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GALAXY GROUPS IN THE THIRD DATA RELEASE OF THE SDSS

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ABSTRACT

We present a new sample of galaxy groups identified in the Sloan Digital Sky Survey Data Release 3. Following previous works we use the well tested friend-of-friend algorithm developed by Huchra & Geller which take into account the number density variation due to the apparent magnitude limit of the galaxy catalog. To improve the identification we implement a procedure to avoid the artificial merging of small systems in high density regions and then apply an iterative method to recompute the group centers position. As a result we obtain a new catalog with 10864 galaxy groups with at least four members. The final group sample has a mean redshift of 0.1 and a median velocity dispersion of 230 $km\ s^{-1}$.
Subject headings: galaxies: clusters : general

1. INTRODUCTION

Galaxy group samples have become a very important issue in cosmology. Since hierarchical clustering drives the structure formation in the universe, galaxy groups can be considered a fundamental piece of the chain joining galaxies and clusters of galaxies.

The information obtained from these systems allows us to understand what the internal processes ruling the intragroup medium are and what the most suitable cosmological model to describe their distribution is.

The first large samples of groups comprised around $\sim$ 1000 galaxy groups and were constructed from different redshift surveys (Merchán, Maia & Lambas 2000, Giuricin et al 2000, Tucker et al. 2000, Ramella et al. 2002). More recently larger galaxy group catalogs were constructed from different releases of the 2dF Galaxy Redshift Survey (hereafter, 2dFGRS). The first one was constructed from the 2dFGRS 100K Data Release by Merchán & Zandivarez (2002) with a total of $\sim$ 2200 groups while using the final release of the 2dFGRS, Eke et al. (2004a) constructed a catalog containing $\sim$ 7000 galaxy groups with at least four members. Research involving these samples comprise studies ranging from local physical properties (Martínez et al. 2002, Domínguez et al. 2002, Díaz et al. 2004, Eke et al. 2004b, Ragone et al. 2004) to large scale structure (Zandivarez, Merchán & Padilla 2003, Padilla et al. 2004).

At the present, the largest galaxy redshift survey is the Third Data Release of the Sloan Digital Sky Survey (hereafter, SDSS-DR3). This release has approximately $\sim$ 530000 spectra of which $\sim$ 380000 are galaxies with a redshift accuracy of 30 $km\ s^{-1}$. The size and deepness of this sample, turns it an ideal source of information to obtain a new galaxy group sample.

The aim of this work is to construct a group catalog from the galaxies in the Third Data Release of the SDSS. The group identification is performed using the algorithm developed by Huchra & Geller (1982). We also apply a technique to improve the identification for groups with at least ten members.

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A description of the group identification algorithm is given in Section 2 while the identification on galaxies and the subsequent improvements are carried out in section 3. Finally, in section 4 we summarize our results.

2. THE GROUP-FINDING ALGORITHM

Group identification is performed using the friend-of-friend algorithm developed by Huchra & Geller (1982). According to these authors, given a pair of galaxies with mean radial comoving distance $D = (D_1 + D_2)/2$ and angular separation θ_{12}, the algorithm links galaxies satisfying the following conditions:

$$D_{12} = 2\sin\left(\frac{\theta_{12}}{2}\right) D \leq D_L = D_0 R \qquad (1)$$

and

$$V_{12} = |V_1 - V_2| \leq V_L = V_0 R \qquad (2)$$

where D_{12} is the projected distance and V_{12} is the line-of-sight velocity difference. Comoving distances D_i are estimated using the relation corresponding to an Einstein-de Sitter model

$$D_i(z) = \frac{c}{H_0}\int_0^z \frac{dz'}{\Omega_M(1+z')^3 + \Omega_\Lambda} \qquad (3)$$

with density parameters $\Omega_M = 0.3$, $\Omega_\Lambda = 0.7$ and $H_0 = 100h\ km\ s^{-1}\ Mpc^{-1}$. The transverse ($D_L$) and radial ($V_L$) linking lengths scale with R, to compensate for the number density variation due to the apparent magnitude limit of the survey. The scaling factor R is computed using the galaxy luminosity function of the sample $\phi(M)$:

$$R = \left[\frac{\int_{-\infty}^{M_{12}} \phi(M)dM}{\int_{-\infty}^{M_{lim}} \phi(M)dM}\right]^{-1/3} \qquad (4)$$

where M_{lim} and M_{12} are the absolute magnitude of the brightest galaxy visible at the fiducial D_f and mean galaxy D distances, respectively. Usually D_0 is chosen in order to obtain the desired overdensity $\delta\rho/\rho$, which is given by

$$\frac{\delta\rho}{\rho} = \frac{3}{4\pi D_0^3}\left(\int_{-\infty}^{M_{lim}} \phi(M)dM\right)^{-1} - 1 \qquad (5)$$

and correspond to a fixed overdensity contour surrounding a group.

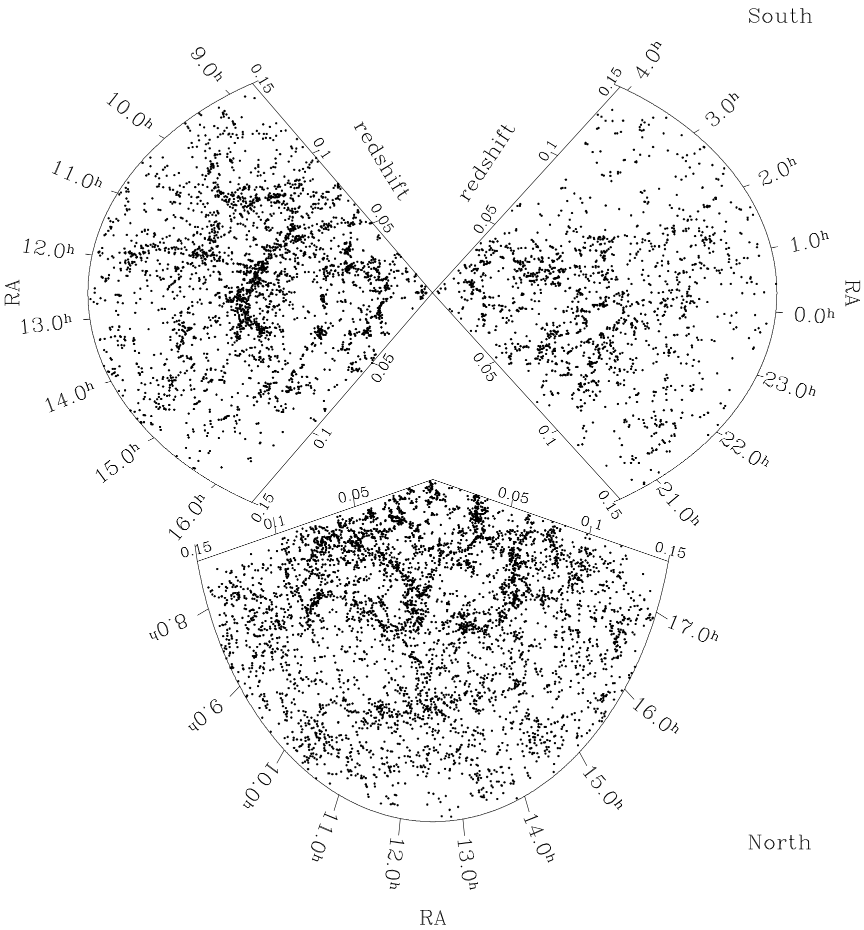

FIG. 1.— Pieplots showing the galaxy groups in the SDSS-DR3. The galaxy groups distribution is showed in three different ranges of right ascension and for redshifts $z \leq 0.15$.

3. GALAXY GROUPS SAMPLE

3.1. *The galaxy catalog*

The Sloan Digital Sky Survey has validated and made publicly available the Third Data Release (Abazajian et al. 2004). This catalog is a photometric and spectroscopic survey covering 4188 deg^2 with five-band ($u\ g\ r\ i\ z$) imaging data and 528640 spectra of galaxies, quasars and stars. In this work we use the main spectroscopic galaxy sample which comprises $\sim$ 300000 galaxies with redshifts $z \leq 0.3$ and an upper apparent magnitude limit of 17.77 in the r-band.

3.2. *Group Identification*

The adopted linking lengths values are motivated by the group identification analysis performed by Merchán & Zandivarez (2002) for the 2dFGRS. Using mock catalogs, they explore a wide range of linking lengths values in order to maximize the group identification accuracy. Since the SDSS-DR3 and 2dFGRS have similar redshift distributions and luminosity functions (Norberg et al. 2002), we choose identical values for the group identification: a transversal linking length corresponding to an overdensity of $\delta\rho/\rho = 80$, a line-of-sight linking length of $V_0 = 200\ km\ s^{-1}$ and a fiducial distance $D_f = 10\ h^{-1}Mpc$. The scaling factor R is estimated using a galaxy luminosity function fitted using a Schecter function with parameters ($\alpha = -1.05 \pm 0.01, M_* - 5\log h = -20.44 \pm 0.01$) given by Blanton et al. (2003). The main properties of the obtained groups sample are summarized in Table 1 (SDSS-DR3 First identification).

3.3. *Rich groups identification improvement*

It should be taken into account that groups obtained from galaxy redshift surveys have unavoidable contamination problems. By instance, the method described previously, can not fully avoid the interloper effect (i.e. spurious inclusion of non-member galaxies), so an artificial merging of small groups with large systems is likely to happen. Recently, working with groups identified in the 2dFGRS Final Release and the First Release of the SDSS, Díaz et al. (2004) have developed a method to minimize this problem on group identification. This method propose a second identification on galaxy groups with at least ten members in order to split merged systems or eliminate spurious member detections. Analyzing group identifications on mock catalogs in real and redshift space, they found that a higher value for $\delta\rho/\rho$ ($\sim$ 315) produce a more reliable group identification. Performing a redshift space identification with this den-

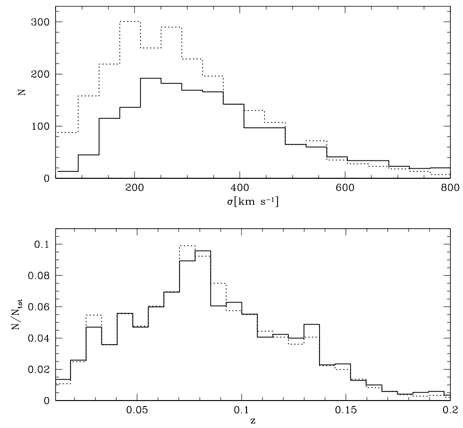

FIG. 2.— Velocity dispersion (upper panel) and redshift (lower panel) distributions for rich groups. The solid line are the distributions for groups with at least ten members after the first identification while the dotted line shows the group distributions when the corrections on the identification has been applied.

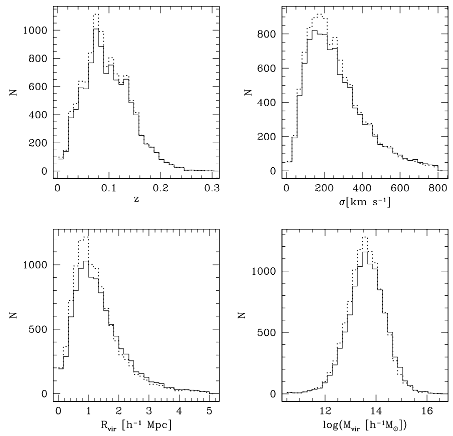

FIG. 3.— Histograms of the redshift (upper-left panel), velocity dispersion (upper-right panel), virial radius (lower-left panel) and virial mass (lower-right panel) distributions of groups in the SDSS-DR3. Solid lines represent the histograms for galaxy groups after the first identification, while dotted lines show the histograms for the galaxy group sample after improving the rich groups identification.

sity contrast is equivalent to a group identification in real space corresponding to $\delta\rho/\rho = 80$. Furthermore, as shown by Mérchan & Zandivarez (2002), adopting lower transversal linking length values, improves the identification accuracy (see Figures 2 and 3 therein). Therefore, following the suggestion of Díaz et al. (2004), we perform a second identification for groups with at least ten members.

A very accurate group center determination is required for some studies related with the galaxy distribution inside groups. Trying to measure density profiles of galaxy groups, Díaz et al. (2004) have also proposed a method for correcting group center position for those systems with at least ten members. Firstly, their method define a new group center estimator by using the projected local number density of each member galaxy for weighting their group center distances. The second part of the method is an iterative procedure to improve the group center location by removing galaxies beyond a given distance and recomputing the center position. The procedure follows until the center location remains unchanged (for more details see section 2 of Díaz et al. 2004). Given that the described procedure needs to compute the projected local number density with five galaxies, this method only can be applied to groups with at least ten members. After applying this correction, the full catalog comprise 9703 galaxy groups with at least 4 members. Figure 1 shows the spatial distribution of groups identified in the SDSS-DR3 with at least 4 members and $z \leq 0.15$.

3.4. *Group physical properties*

In addition to the group identification, we also estimate its basic physical properties such as velocity dispersion, virial radius and virial mass.

The line-of-sight velocity dispersion σ_v, is estimated using the methods described by Beers, Flynn & Gebhardt (1990). The biweight estimator is applied for groups with richness $N_{tot} \geq 15$ whereas the gapper estimator is applied to poor groups (Girardi et al. 1993, Girardi & Giuricin 2000). Following Eke et al. (2004) we also introduce a correction due to the error in the redshift measurement. This is a second order correction since the redshift measurement error in the SDSS is 30 $km\ s^{-1}$. The virial radius is estimated using the following equation

$$R_V = \frac{\pi}{2}\frac{N_g(N_g-1)}{\sum_{i>j} R_{ij}^{-1}} \qquad (6)$$

where N_g is the number of galaxy members and R_{ij} the galaxy projected distances.

Finally the virial masses of galaxy groups is computed as

$$M_V = \frac{3\sigma_v^2 R_V}{G} \qquad (7)$$

where G is the gravitational constant.

Individual group velocity dispersion estimation, allow us to observe rich group reideintification and recentering consequences. Figure 2 illustrate the rich group ($N_g \geq 10$) velocity dispersion behavior (upper panel) for groups before and after correction (dotted and solid lines, respectively). As can be seen, the distribution of groups with high velocity dispersions ($\sigma_v \gtrsim 300\ km\ s^{-1}$) remains unchanged, whereas artificially merged groups in the first identification, now appears as a new population with low velocity dispersion. The redshift distribution for groups with at least ten members is shown in the lower panel of Figure 2, It should be noted that the correction applied to rich groups do not introduce any bias with redshift. Histograms showing the distribution of redshift, velocity dispersion, virial radius and virial mass of groups with at least 4 members are plotted in Figure 3. Finally the median physical properties of the full group catalog are quoted in Table 1.

4. CONCLUSIONS

We present the largest galaxy groups catalog at the present constructed from galaxies in the Third Data Release of the Sloan Digital Sky Survey. The group identification is carried out using the friend-of-friend algorithm

TABLE 1
Median physical properties of groups

Sample	N	N_{gal}	$\bar{z}$	$\bar{\sigma}_v(km\ s^{-1})$	$\bar{M}(h^{-1}M_{\odot})$	$\bar{R}_V(h^{-1}Mpc)$
USGC (Ramella et al., 2002)	1168	6846	—	264	4.7×10^{13}	1.06
LCRS Loose Groups (Tucker et al., 2002)	1495	~ 9250	—	164	1.9×10^{13}	~ 1.2
2dFGRS (Mechán & Zandivarez, 2002)	2209	14634	0.1	232	3.7×10^{13}	1.02
2dFGRS (Eke et al., 2004a)	7020	55753	0.11	260	3.3×10^{13}	—
SDSS-DR3 First identification	10152	78410	0.1	240	4.2×10^{13}	1.21
SDSS-DR3 Improved identification	10864	66517	0.1	230	3.8×10^{13}	1.12

developed by Huchra & Geller (1982), plus the introduction of corrections for rich groups which improve the group identification and the group center location. The resulting catalog comprise 10864 galaxy groups with at least four members and it has a mean redshift of 0.1. The median basic physical properties of our catalog are very similar to those obtained in previous works (Table 1).

The complete galaxy group catalog with the physical properties estimated in this work is available in the World Wide Web at *https://www.iate.oac.uncor.edu/SDSSDR3GG/* or upon request at any of the following e-mail addresses: *manuel@oac. uncor.edu, arielz@oac.uncor.edu.*

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