THE ESO NEARBY ABELL CLUSTERS SURVEY (ENACS): VELOCITY DISPERSION DISTRIBUTION

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Abstract

We use a set of 91 clusters observed in the course of the ESO Nearby Abell Cluster Survey (ENACS) and another 37 clusters taken from the literature in order to construct a volume-limited sample of nearby clusters (z <0.08). We define the 3–dimensional Abell richness class R_{3D} and we evaluate the spatial density of clusters with R_{3D} $\geq$1. For a subset of 43 clusters with N$\geq$10 members and with richness class R_{3D} $\geq$1 we evaluate the distribution function of the cluster velocity dispersions.

1 Introduction

One of the goals of the ESO Nearby Abell Cluster Survey (ENACS) was to collect redshifts and magnitudes for a complete, volume–limited sample of the 140 R$\geq$1 clusters from the ACO catalogue[1], in a cone around the southern galactic pole defined by $b \leq -30°$ and $\delta \leq 0°$, up to z=0.1 or m_{10}=17. During 35 nights on the ESO 3.6 m we have obtained about 5,500 redshifts in 106 clusters. We observed between 1 and 6 OPTOPUS plates for each cluster, obtaining from a few up to almost 300 redshifts per cluster. R-band magnitudes were obtained from a combination of CCD and photography photometry. We have supplemented our sample with about 1,000 redshifts in 37 clusters collected from the literature.

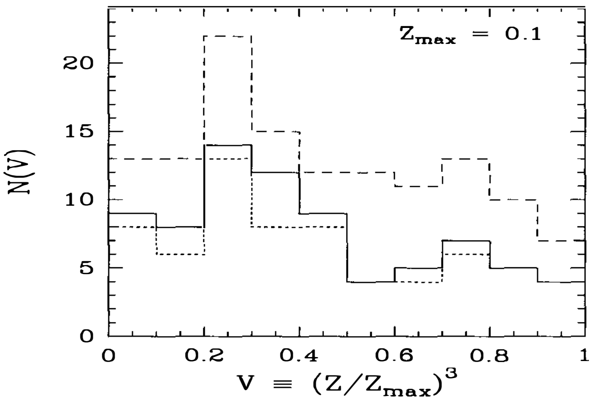

Figure 1: The volume test for uniform sampling. The number of clusters is plotted for 10 concentric shells each with a volume equal to one-tenth the total volume out to z=0.1, which is taken unity. The dashed line represents all clusters in the sample, the solid line the clusters with $N \geq 10$, and the dotted line the clusters with $R_{3D} \geq 1$.

2 A volume-limited sample of clusters

In order to construct a volume-limited sample of clusters we have taken the following steps. First, cluster members must be separated in redshift space from foreground and background galaxies. We have defined the redshift limits on either side of the cluster using the first gap between adjacent galaxies that is larger than 900 km/s; when two galaxies have a velocity difference greater than the chosen gap, they are ascribed to different systems. This value is an optimal value given the aperture and average depth of the individual surveys. For N≥10 systems both N and velocity dispersion σ_V change very little when the gap size is varied by 100 km/s, or when more elaborated schemes, e. g. gaps weighted with N or σ_V are used.

Second, we deal with projection effects along the line of sight by introducing a 3-dimensional equivalent of ACO's richness class, R_{3D}. We find that, on average, ~75% of the observed galaxies is in the main system, while ~25% is in foreground or background. Thus, of the 50 galaxies that are required within $[m_3, m_3{+}2]$ and 1.5 h^{-1} Mpc around the centre to have a R=1 cluster, 38 objects are on average within the cluster itself. Therefore, we define that $R_{3D} \geq 1$ if the counts of ACO, C_{ACO}, times the fraction of measured redshifts that are in the main system, f_{main}, is $C_{3D} = C_{ACO} \times f_{main} \geq 38$.

Third, we define an optimal depth for the sample. If we divide the volume of the above defined "cone" up to z=0.1 into 10 concentric shells, we find that we sample the clusters with at least 10 members with known redshift up to z=0.08 with a roughly constant spatial density, whereas beyond this limit the density drops by a factor half (see Fig.1). Therefore, we take z=0.08 as the limit of our sample. Of the 58 $N \geq 10$ clusters with $z \leq 0.08$, 43 clusters have $R_{3D} \geq 1$.

Fourth, we have to correct for the incompleteness of this subsample of 43 clusters, by accounting for the clusters with not enough redshifts available to determine C_{3D}. From the C_{ACO} and f_{main} distributions, we estimate that there should be 25 more clusters with $C_{3D} \geq 38$

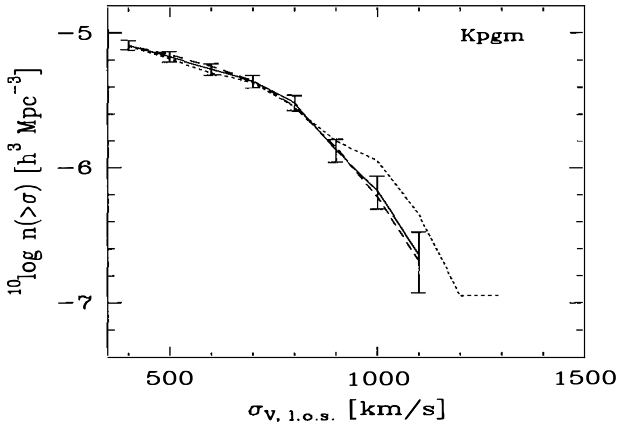

Figure 2: The cumulative distribution of velocity dispersions of clusters. Solid line: $n(>\sigma_V)$ for 77 clusters with $C_{ACO} \geq 50$ and $z \leq 0.1$ (main systems only). Dotted line: idem, but σ_V not corrected for interlopers. Dashed line: $n(>\sigma_V)$ for 43 clusters with $C_{3D} \geq 38$ and $z \leq 0.08$.

in our "cone".

The estimated total number of systems in our "cone" with $C_{3D} \geq 38$ is therefore 68, which yields a co-moving density of $6.5 \times 10^{-6} h^3 Mpc^{-3}$. This number has to be corrected for two effects: (1) incompleteness of the ACO catalogue, which is estimated by comparison with the Edimburgh-Durham Cluster Catalogue[2]; (2) Galactic obscuration[3,4]. Accounting for these two effects brings the estimate of co-moving density of rich clusters to $8.8 \times 10^{-6} h^3 Mpc^{-3}$ in substantial agreement with previous estimates[3,5,6].

3 The Distribution of Velocity Dispersions

We calculate the cluster velocity dispersions σ_V using the robust biweight estimator[7]. For the clusters with N>50 we have removed probable interlopers by applying a new iterative method that uses the combined information of velocities and position[8]. Fig.2 shows the resulting cumulative distribution function of the line-of-sight velocity dispersion for our 43 clusters with $z < 0.08$, $N \geq 10$ members, $R_{3D} \geq 1$. In Fig.3 we compare our distribution with previous results: we find less clusters with large velocity dispersion than previous studies did[9,6]

Our results stress that a fair identification of cluster members considerably reduces the fraction of clusters with high velocity dispersion. Incidentally, compared with the predicted distributions of velocity dispersion which result from cosmological N–body simulations[10] for the standard Ω=1 CDM scenario with various values of the bias parameter b, our results would agree with a high value of b ($b \sim 2.5$).

It can be seen in Fig.3 that in the range $\sigma_V \geq 800$ km s^{-1} our new σ_V–distribution is in perfect agreement with the temperature-distribution[11] of the X-ray emitting intracluster plasma when the isothermal relation T$\propto \sigma_V^2$ is adopted. The disagreement between the two distributions at low σ_V is due to the fact that our sample is complete only for optically rich clusters, and we lack poor clusters and groups, whilst these systems are present in the sample used to derive the temperature distribution.

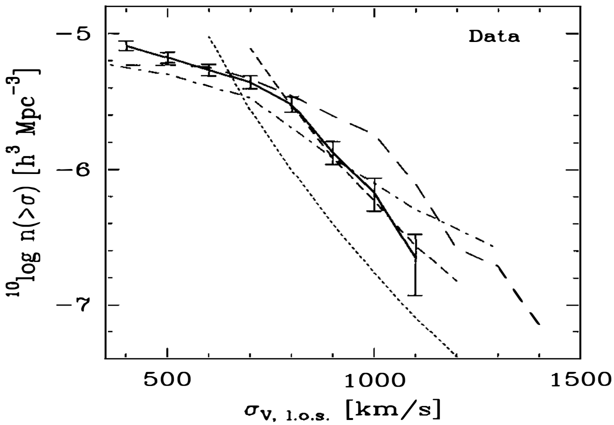

Figure 3: Comparison of the present cumulative distribution of velocity dispersions (solid line) with distributions from the literature: velocity dispersion distributions of Girardi et al.[9] (long-dashed line), and Zabludoff et al.[6] (dashed-dotted line); X-ray emitting gas temperature distributions of Henry & Arnaud[11] (short-dashed line), and Edge et al.[12] (dotted line).

4 References

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