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THE TWO-POINT CORRELATION FUNCTION FOR GROUPS OF GALAXIES IN THE CENTER FOR ASTROPHYSICS REDSHIFT SURVEY

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ABSTRACT

We compute the two-point correlation function, ξ_{GG}, in redshift space for the groups of galaxies identified by Ramella, Geller, and Huchra from the extension of the Center for Astrophysics (CfA) redshift survey. The group catalog includes galaxies with $m_{B(0)} \leq 15.5$ and covers the right ascension range $8^h \leq \alpha \leq 17^h$ and the declination range $26°.5 \leq \delta < 38°.5$. The amplitude and slope of ξ_{GG} agree with the values for the galaxy correlation function computed for the same region. These results also hold for a larger sample which covers the same right ascension range and the declination range $26°.5 \leq \delta < 44°.5$. The amplitude of ξ_{GG} is consistent with an extrapolation of the amplitude-richness relation for rich clusters (see Bahcall) and with the density scaling of the cluster correlation function suggested by Szalay and Schramm.

We examine the contribution of members of groups to the galaxy correlation function. We show that on scales less than $\sim 3.5h^{-1}$ Mpc intragroup pairs dominate the correlation function (the Hubble constant $H_0 = 100h$ km s^{-1} Mpc^{-1}). On larger scales intergroup pairs are the largest contributors. Regardless of the density contrast for group selection, the "field" remains weakly correlated.

Subject headings: galaxies: clustering — galaxies: redshifts

I. INTRODUCTION

Individual galaxies and clusters of galaxies are not equivalent tracers of the large-scale matter distribution in the universe (Peebles 1980; Kaiser 1984; Szalay and Schramm 1985, hereafter SS85). The large amplitude of the two-point correlation function for clusters (Bahcall and Soneira 1983 [hereafter BS83]; Klypin and Kopylov 1983; Batuski and Burns 1985; Shectman 1985; Postman *et al.* 1986; Shvartsman 1988) relative to that for individual galaxies (Davis and Peebles 1983; de Lapparent, Geller, and Huchra 1988, hereafter dGH) is an observational constraint which many models cannot easily meet (see, for example, Kaiser 1984; White *et al.* 1987; Weinberg, Ostriker, and Dekel 1989; Davis and Efstathiou 1988).

Because clusters are identified as density enhancements on the sky (Abell 1958; Zwicky *et al.* 1961–1968) it is difficult to reproduce the selection procedure in an N-body model (Frenk *et al.* 1989). However, group catalogs (Maia da Costa, and Latham 1989; Ramella, Geller, and Huchra 1989) large enough for calculation of a correlation function can now be extracted from complete redshift surveys. Exactly the same objective group-finding algorithms can be applied to simulations (see, e.g., Nolthenius and White 1987). Thus the statistics of the distribution of groups could be used to evaluate the adequacy of the models.

Jing and Zhang (1988) and Maia and da Costa (1989) calculate the group correlation function for the original CfA survey (Huchra *et al.* 1983) and for the Southern survey (da Costa *et al.* 1988), respectively. They find, rather surprisingly, that the amplitude of the group correlation function is significantly lower than that of the galaxy correlation function. These results disagree with the predictions of models like the one proposed by Kashlinsky (1987): the correlation function amplitude for systems must be at least as large as for individual galaxies.

Here we examine the large-scale distribution of groups of galaxies selected from complete slices of the CfA redshift survey extension. We describe the data in § II. In § III we use the redshift survey to reexamine the contribution of group members to the galaxy correlation function. This issue was considered by Turner and Gott (1975) before the availability of complete large-scale redshift surveys. Section IV describes the calculation of the group correlation function. Section V is a discussion of the relationship between the correlation function for groups and those calculated for rich clusters. We examine the results for groups as an extension of the relation between correlation function amplitude and richness. Our conclusions are in § VI.

II. THE REDSHIFT SURVEY AND THE GROUP CATALOG

Ramella, Geller, and Huchra (1989, hereafter RGH) identified groups of galaxies in the first two complete strips of the CfA redshift survey extension (Huchra *et al.* 1990). The region of the sky covered by the two strips is $8^h \leq \alpha \leq 17^h$, $26°.5 \leq \delta < 38°.5$, corresponding to a solid angle of 0.42 sr. Here we limit our analysis to the 1672 galaxies in the two strips with $cz < 12{,}000$ km s^{-1} and with $m_{B(0)} \leq 15.5$.

We adopt the galaxy luminosity function from dGH. The values of the parameters are consistent with the more detailed analysis by de Lapparent, Geller, and Huchra (1989; see their Table 1). Magnitudes are on the Zwicky-B(0) system, and we make no absorption correction. We parameterize the luminosity function $\phi(M)$ according to the Schechter (1976) form with amplitude $\phi^* = 0.025$ galaxies mag^{-1} Mpc^{-3}; characteristic magnitude $M^*_{B(0)} = -19.15$; and faint end slope $\alpha = -1.2$. The corresponding luminosity density is 2.05×10^8 $L_\odot$ Mpc^{-3}.

RGH contains a full account of the group identification procedure and of its limitations. Here we summarize a few particularly relevant points. We produced the group catalog by applying an objective algorithm which searches for "friends of friends" in redshift space (Huchra and Geller 1982). Galaxies in a group are separated by line-of-sight velocity $V \leq V_L =$

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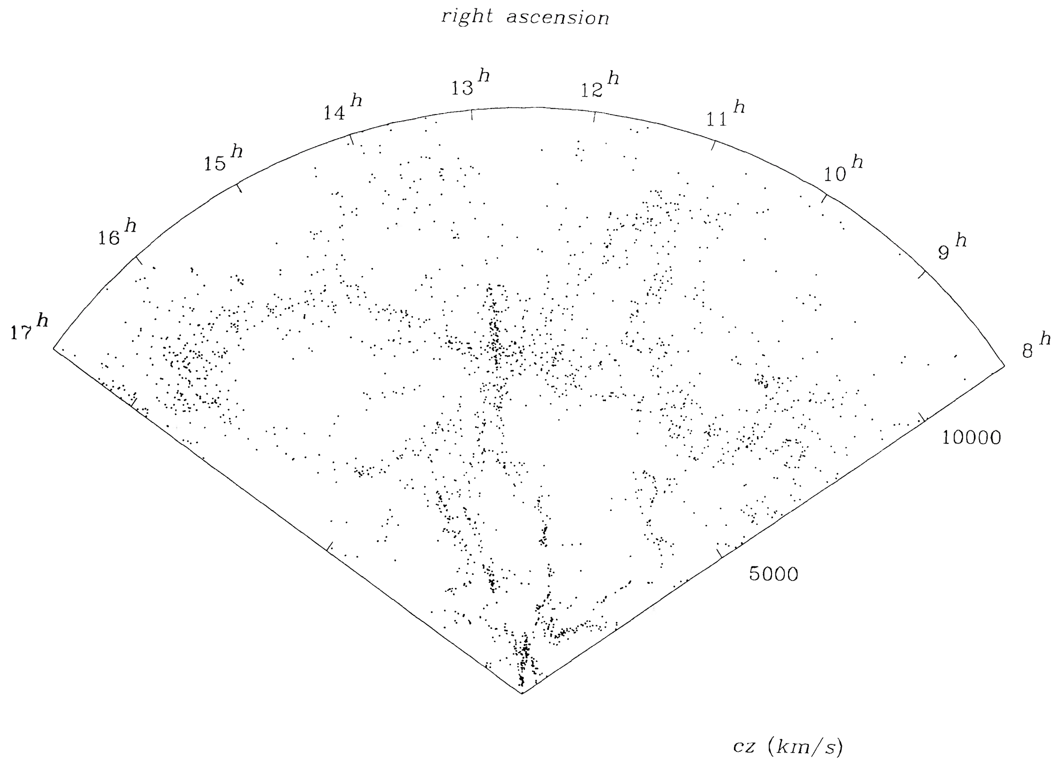

FIG. 1*a*

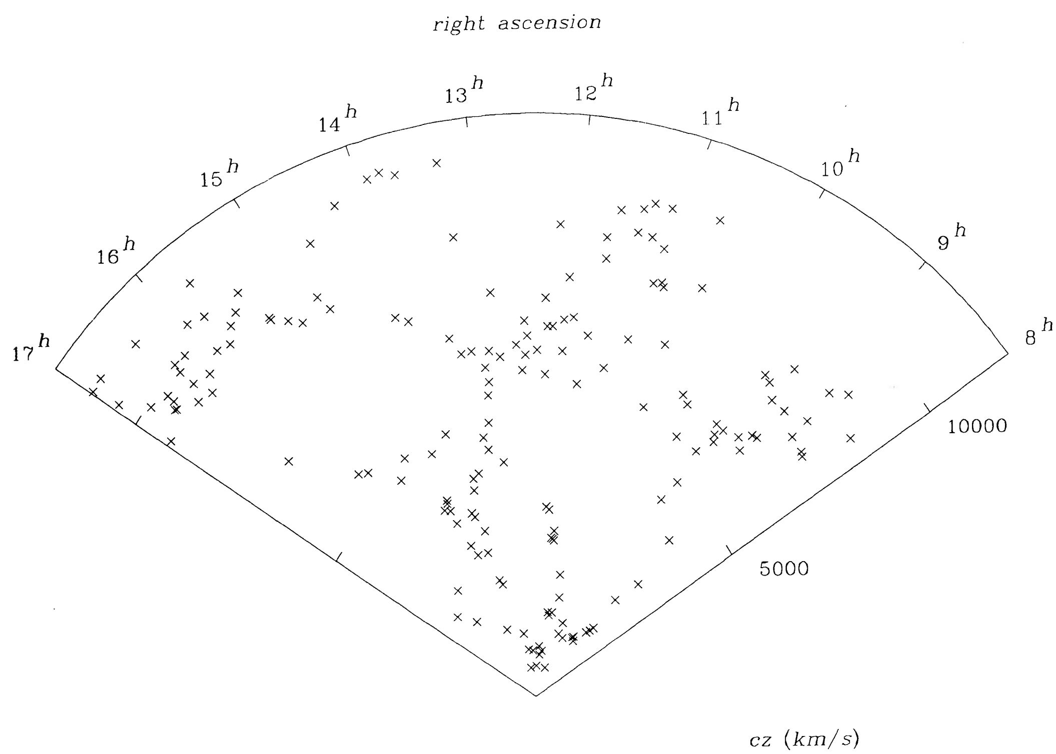

FIG. 1*b*

FIG. 1.—Cone diagrams for the declination range $26^\circ.5 \leq \delta \leq 44^\circ.5$. The plots contain (*a*) 2355 galaxies with $m_{B(0)} \leq 15.5$ and $cz \leq 12{,}000$ km s^{-1}, (*b*) 173 groups with $N_{\rm mem} \geq 3$, and (*c*) 614 galaxies not assigned to a group or binary (the "field").

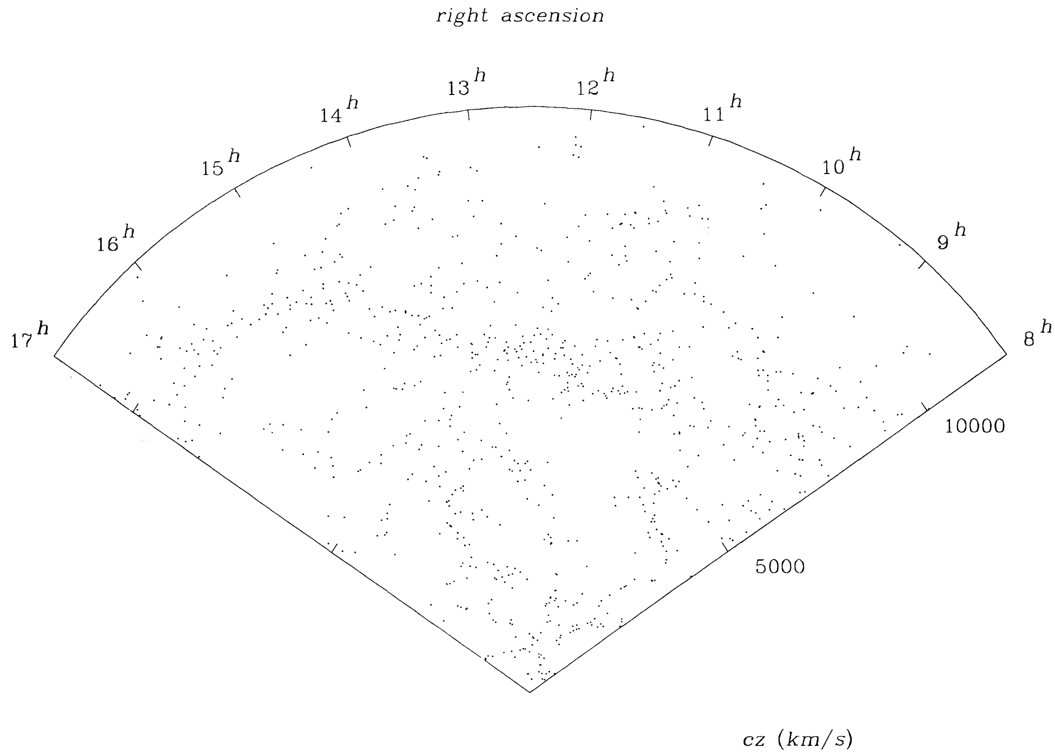

FIG. 1c

$V_0 R$ and projected separation $D \le D_L = D_0 R$. Both D_L and V_L are scaled with redshift to account for the magnitude limited sampling; R is the scaling factor. The choice of D_0 fixes the minimum number density enhancement $\delta\rho/\rho$ of a group relative to the global mean. For the RGH catalog $D_0 = 0.27h^{-1}$ Mpc corresponding to a number density threshold of $\delta\rho/\rho = 80$. We take $V_0 = 350$ km s^{-1}. As explained in RGH these choices minimize problems with interlopers.

The catalog contains 128 groups with at least three members and 56 with at least five members; there are 774 group members with $cz < 12{,}000$ km s^{-1}. The algorithm also identifies 140 binary systems. Our statistical confidence in the reality of the binary systems in low; in fact, we estimate that 33% of the triples are probably accidental superpositions. Section IV contains the statistical analysis of this group catalog.

A third complete slice of the CfA redshift survey covers the ranges $38^\circ\!.5 \le \delta < 44^\circ\!.5$ and $8^{\rm h} \le \alpha \le 17^{\rm h}$ (Geller 1987). In all three slices there are 2355 galaxies with $cz < 12{,}000$ km s^{-1}. This third slice has not yet been as carefully analyzed as the other two. Assuming the same global luminosity function, we identified groups as in RGH. In the three slices together we find 73 groups (71 with at least five members), 206 binaries, and 835 "field" galaxies. Figures 1*a*, 1*b*, and 1*c* show galaxies, groups and "field" galaxies in these three slices. Similar plots for the first two slices are in RGH (their Figs. 1, 4*a*, and 4*b*). We use the larger group sample to demonstrate the robustness of the results for the first two slices.

III. CALCULATION OF CORRELATION FUNCTIONS

We compute the two-point correlation function $\xi(s)$ as a function of the separation in redshift space:

$$s = \frac{(V_i^2 + V_j^2 - 2V_iV_j \cos \theta_{ij})^{1/2}}{H_0} \tag{1}$$

where V_i and V_j are the velocities of two galaxies (groups) separated by an angle θ_{ij} on the sky and H_0 is the Hubble constant. As in Davis and Peebles (1983) and dGH88, we use

$$\xi(s) = \frac{N_{\rm DD}(s)}{N_{\rm DR}(s)} - 1 \tag{2}$$

as the estimator of $\xi(s)$. Here $N_{\rm DD}(s)$ is the number of pairs with separation $(s, s + ds)$ in the data. $N_{\rm DR}$ is the number of pairs at separation $(s, s + ds)$ with one point in the data (D) and the other in a random "control sample" (R). The "control sample" contains randomly distributed points in the volume filled by the data. The geometry for the random sample and the selection function

$$p(v) = \frac{\int_{-\infty}^{M(v)} \phi(M)dM}{\int_{-\infty}^{M(v_{\min})} \phi(M)dM} \tag{3}$$

are the same as for the data. Here $M(v)$ is the absolute magnitude of the faintest galaxy included in the sample at velocity v and $M(v_{\min})$ is the absolute magnitude of the faintest galaxy included at a fiducial minimum velocity of 300 km s^{-1}. The "control sample" accounts for edge effects caused by the "slice-like" geometry of the survey.

We calculate correlation functions for (1) all galaxies ($\xi_{\rm gg}$), (2) "members" ($\xi_{\rm mm}$), (3) "field" galaxies ($\xi_{\rm ff}$), and (4) groups ($\xi_{\rm GG}$). Here "members" are all galaxies in the systems of galaxies identified in RGH; for this study we include galaxies in "binaries" among "members." The "field" galaxies are those not assigned to groups or binaries. We use the same form of the selection function for all of these samples. We vary only the normalization to account for the different sample sizes. Figure 2 shows that this approach is reasonable. The redshift distributions for all of these samples are indistinguishable.

Our sample of groups is small and thus the uncertainty in

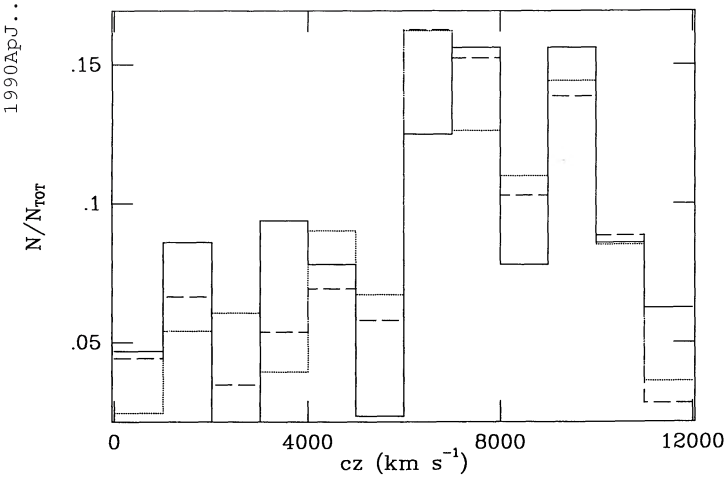

FIG. 2.—Redshift distribution for (*a*) galaxies (*dashed line*), (*b*) groups (*solid line*), and (*c*) field galaxies (*dotted line*) in the declination range $26°.5 \leq \delta \leq 38°.5$. The distributions are normalized to the total number of objects in each sample.

the selection function is large. For this reason we have chosen not to weight the calculation of the correlation function inversely with selection function, $p(v)$. Because of the large-scale coherent structures in the survey, the choice of weighting of the points in the calculation of a correlation function has a significant effect on its amplitude (see LGH 88). Here, we are primarily interested in the relative amplitudes of correlation functions for the four sets of points described above. Because all of the samples trace the same large-scale structures, the relative amplitudes are unaffected by the weighting.

Each of the correlation functions we calculate is an average of correlation functions computed for 40 different realizations of the control sample. Forty realizations are sufficient to produce a stable mean. The dispersion of the correlation functions around the mean, $\sigma_\xi(s)$, yields our estimate of the Poisson errors. This estimate is a lower limit to the uncertainty because points at different separation s are not independent (see Kaiser 1986). There may also be systematic errors in the determination of the correlation function. These include the difficulty of determining the appropriate mean density. In fits to power-law approximations, variations in the range of the fit and in the point weighting scheme may introduce additional significant variations in the derived parameters.

III. GALAXIES, "MEMBERS," AND THE "FIELD"

Here we calculate the correlation function for "members." We then examine the contribution for inter- and intrasystem (a system is a group or binary) pairs to this correlation function. We show that on scales less than $\sim 3h^{-1}$ Mpc intrasystem pairs dominate the correlation function and on scales from 3–$10h^{-1}$ Mpc intersystem pairs make the largest contribution. The "field" is more weakly correlated by construction of the group catalog; however, its distribution is *not* random.

Figure 3 shows the galaxy correlation function and the correlation function ξ_{mm} for group members. A fit of ξ_{mm} to a power-law form

$$\xi(s) = \left(\frac{s}{s_0}\right)^\gamma \quad (4)$$

over the range 3–$10h^{-1}$ Mpc gives $s_0 = 8.0h^{-1}$ Mpc, $\gamma = -1.3$. The uncertainties are $\sim 20\%$ in s_0 and $\sim 10\%$ in γ. This amplitude is slightly larger than the $s_0 = 5.2h^{-1}$ for ξ_{gg}. For ξ_{gg}, $\gamma = -1.3$. Again the uncertainties are $\sim 20\%$ in s_0 and 10% in γ.

Figure 3 also shows the correlation function for "field" galaxies, ξ_{ff}, which has a significantly lower amplitude than ξ_{mm}. For ξ_{ff}, $s_0 = 2.3h^{-1}$ Mpc and $\gamma = -1.5$. The cross-correlation function ξ_{mf} has a similarly low amplitude. Both groups and the field trace the large-scale pattern in the distribution of galaxies (see Figs. 1*b* and 1*c*). The scale of ξ_{ff} is comparable with the thickness of the structures. For groups selected at lower density contrast, the "field" is less correlated but *not* randomly distributed (Turner 1975).

One subtlety in the calculation of ξ_{ff} is that there are "holes" in the distribution where group members have been extracted. Failure to correct for these in the random control samples can lead to a spurious anticorrelation in ξ_{ff} on the scale of individual groups. To eliminate this problem, we introduce "holes" in the random control samples at the positions of groups in redshift space. The size of a "hole" is twice the mean pairwise separation and 4 times the velocity dispersion of the group located at that position. With this choice, making these "holes" in the actual data extracts all but five group members.

Figure 3 shows that, as we would expect, "members" are the dominant contributors to the galaxy correlation function. We can decompose ξ_{mm} to examine the relative contribution of intrasystem and intersystem pairs to the correlation function. Figure 4 shows $\xi_{intra} + 1$ and $\xi_{inter} + 1$ along with $\xi_{mm} + 1 = \xi_{intra} + \xi_{inter} + 2$. The slope of ξ_{intra} is roughly equal to -2 because on small scales the correlation function samples primarily the velocity dispersion of the groups. Groups are essentially one-dimensional structures "stretched" out along the redshift direction by peculiar velocities. This component dominates ξ_{mm} (and ξ_{gg}) on scales $\lesssim 3h^{-1}$ Mpc, roughly the scale of a typical group. The slope of ξ_{inter} is shallower and is mainly determined by the relative positions of groups in the survey

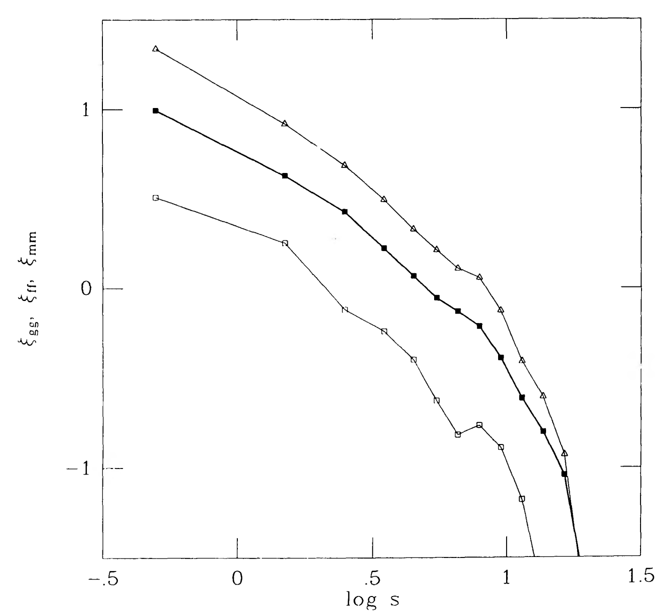

FIG. 3.—Two-point correlation functions for (*a*) members, ξ_{mm}, (*open triangles, thin line*), (*b*) field, ξ_{ff}, (*open squares, thin line*), and (*c*) all galaxies, ξ_{gg}, (*squares, thick line*) in the declination range $26°.5 \leq \delta \leq 38°.5$. In this plot the $1\,\sigma$ Poisson error bars would be slightly larger than the symbol size.

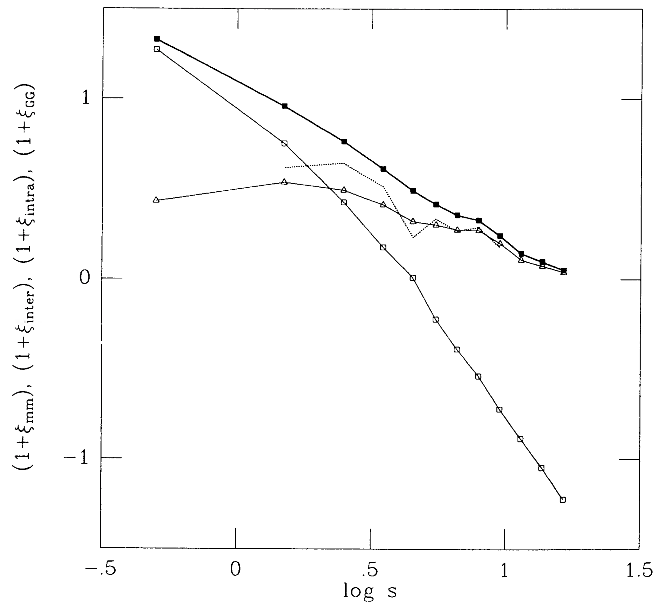

FIG. 4.—Decomposition of the two-point correlation function for members (*thick line*): (*a*) contribution of members within groups (*squares*) and (*b*) contribution of members assigned to different groups (*triangles*). The dotted line shows the two-point correlation function for groups. We plot $(1 + \xi)$ for all samples.

(and by the number of members in each group) or, equivalently by the large-scale structure in the region.

IV. GROUP-GROUP CORRELATION FUNCTION

Figure 5 shows the group-group correlation function, $\xi_{GG}(s)$, for the 128 groups in the catalog with three or more members. The error band shows the 1 σ limits. On scales $\lesssim 1.5h^{-1}$ Mpc groups are, by definition, anticorrelated. A χ^2 fit of the group-group correlation function to a power law (eq. [4]) gives $s_0 = 6.0h^{-1}$ Mpc and $\gamma = -1$, over the range 3–$10h^{-1}$ Mpc. At larger scales $\xi_{GG}(s)$ falls below the noise level. We weight the fit inversely with σ_ξ. The uncertainty in the correlation length is a factor of 2.5; the uncertainty in the exponent is $\sim 50\%$. These results are unaffected by (1) a change in the density threshold for groups to $\delta\rho/\rho = 20$ and (2) inclusion of binaries in the $\delta\rho/\rho = 80$ sample.

For comparison, Figure 5 also shows ξ_{gg}. Remarkably, the correlation functions for groups and for galaxies are equal to within the 1 σ errors. For both ξ_{gg} and ξ_{GG} the systematic errors are larger than the Poisson errors. For example, the slope of ξ_{gg} is $\gamma = -1.5$ (as compared with $\gamma = -1.3$) if the range of the fit extends to $14h^{-1}$ Mpc and even steeper if the fit is unweighted ($\gamma = -1.7$; see dGH 88). Figure 4 shows the coincidence of ξ_{GG} with ξ_{inter} for $s \gtrsim 5h^{-1}$ Mpc.

Because the sample of groups is small, we use the larger three-slice catalog (173 groups) to test the robustness of our results. Figure 6 shows the correlation functions ξ_{gg} and ξ_{GG} for this sample along with the corresponding correlation functions for the two-slice sample. The results for ξ_{GG} agree to within the 1 σ errors. Fits to power laws for the three-slice correlation functions yield somewhat steeper slopes than those obtained for two slices. Because the true errors in the determination of these correlatin functions are large, we do not regard these differences as significant.

Although groups and the field appear to trace the same large-scale features of the galaxy distribution, their correlation functions differ on scales $\lesssim 10h^{-1}$ Mpc. Groups are not a random sampling of positions occupied by "field" galaxies but are more clustered. Samples of 128 galaxies drawn from the "field" are less ordered along sheets than groups are. The mean correlation function for samples drawn from the "field" is ξ_{ff}. One might worry that the "field" has holes at the group positions. At the local density of the "field" we would expect, on average, ~ 60 additional "field" galaxies at group and/or binary positions. Even if we place an additional "field" galaxy

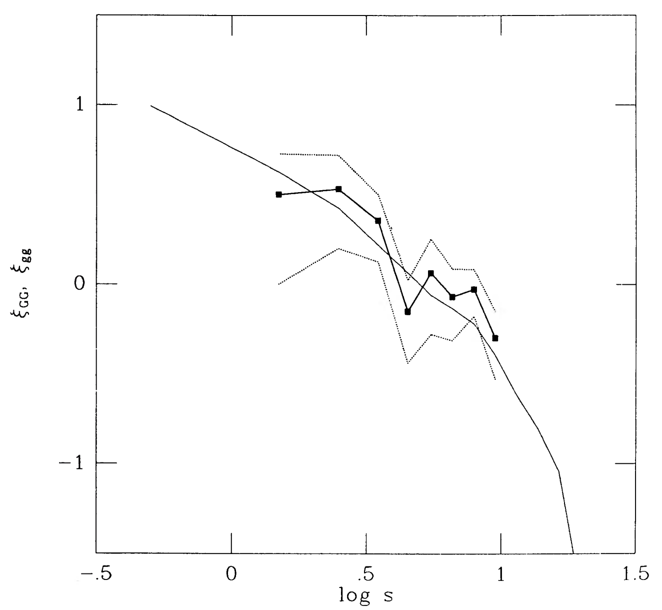

FIG. 5.—Two-point correlation function, ξ_{GG}, for 128 groups ($N_{mem} \geq 3$) in the declination range $26^\circ\!.5 \leq \delta \leq 38^\circ\!.5$ (*thick line*). The dotted lines mark the $\pm 1\ \sigma$ band of ξ_{GG}. The thin line represents ξ_{gg}.

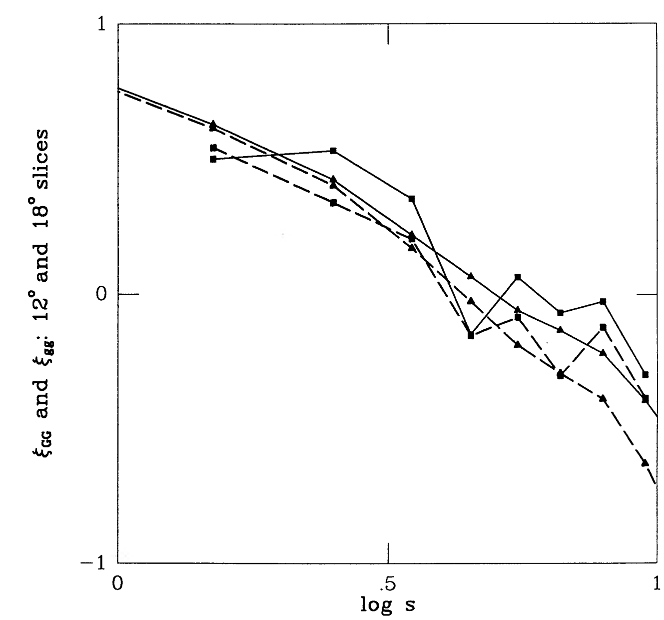

FIG. 6.—Two-point correlation functions for the samples in the 18° slice (*dashed lines*) and in the 12° slice (*solid lines*): (*a*) all galaxies (*triangles*) and (*b*) groups (*squares*). Error bars are omitted for clarity.

at each group and binary position, a random sampling still produces ξ_{ff}.

V. RELATIONSHIP BETWEEN CORRELATION FUNCTIONS FOR GROUPS AND CLUSTERS

Over the last few years, the high amplitude for the correlation function of rich clusters has been widely discussed. With the power-law form in equation (4), the correlation function for rich clusters has $s_0 = 14$–$25h^{-1}$ Mpc with $\gamma = -1.8$. The amplitude is a function of the richness of the clusters. In this section we first discuss the relationship between our groups and the clusters identified by Abell and/or Zwicky. We then ask whether the amplitude of the group correlation function is consistent with an extrapolation of the relationship between cluster richness and the amplitude of the cluster correlation function.

Within the range of the survey there are seven Abell clusters, four with Abell richness class R = 0, two with R = 1, and one with R = 2 (Coma classified according to Abell). These clusters are all groups in our catalog: the R = 0 clusters have five to six members, the R = 1 clusters have eight and 13 members, and Coma has 139 members. If we ask how many groups have at least the same number of members as the poorest clusters ($N_{mem} > 4$), at least the same line-of-sight velocity dispersion ($\sigma_v > 200$ km s^{-1}) and a mean redshift $cz > 6000$ km s^{-1} (Abell estimates that he can identify clusters at redshifts greater than this limit), we find 20 such "cluster-like" groups (in addition to the Abell clusters). Six of these are similar to R = 1 Abell clusters. Eighty percent of our R = 0 and R = 1 "cluster-like" groups are also nearby Zwicky clusters. Zwicky classified about half of them as "open" and half as "medium compact." These classifications are similar to those Zwicky applies to the clusters also identified by Abell. These comparisons indicate that Abell may have missed some nearby systems. Figure 7 shows that, in addition, Abell clusters (marked with arrows) seem to be a biased sample of the cluster-like groups. The wedge diagram shows the distribution of R = 0 and R = 1 cluster-like groups including the seven found in the third slice (four of these are R = 1, two are R = 2; one of the groups in the third slice corresponds to two Abell clusters: A2197 and A2199 which are so close together that the algorithm cannot separate them). The complete identification of nearby R = 1 clusters is particularly important because poorer systems, being more numerous, dominate the determination of the cluster correlation function.

The 56 groups with at least five members produce an unreasonably noisy correlation function. However we can determine whether the Abell clusters are a random sample of these systems. We repeatedly extract random samples of seven groups from the sample of 56 rich groups and compute the distribution of distances among each set of seven groups. A KS test indicates that the distribution of these distances differs at the 95% confidence level from the distribution of the distances between pairs of Abell clusters.

Our group-group correlation function cannot be compared directly with typical determinations of the cluster-cluster correlation functions, ξ_{CC}, because the range of scales over which they are determined do not overlap. A scale of $\sim 10h^{-1}$ Mpc is generally the smallest scale point for ξ_{CC} and the largest reliable scale for ξ_{GG}. However, Postman, Geller, and Huchra (1986) show that the amplitude of the correlation function for Zwicky clusters is consistent with a random sampling of the galaxy distribution; in other words the amplitude is the same as for ξ_{gg}. Our correlation function for groups selected in red-

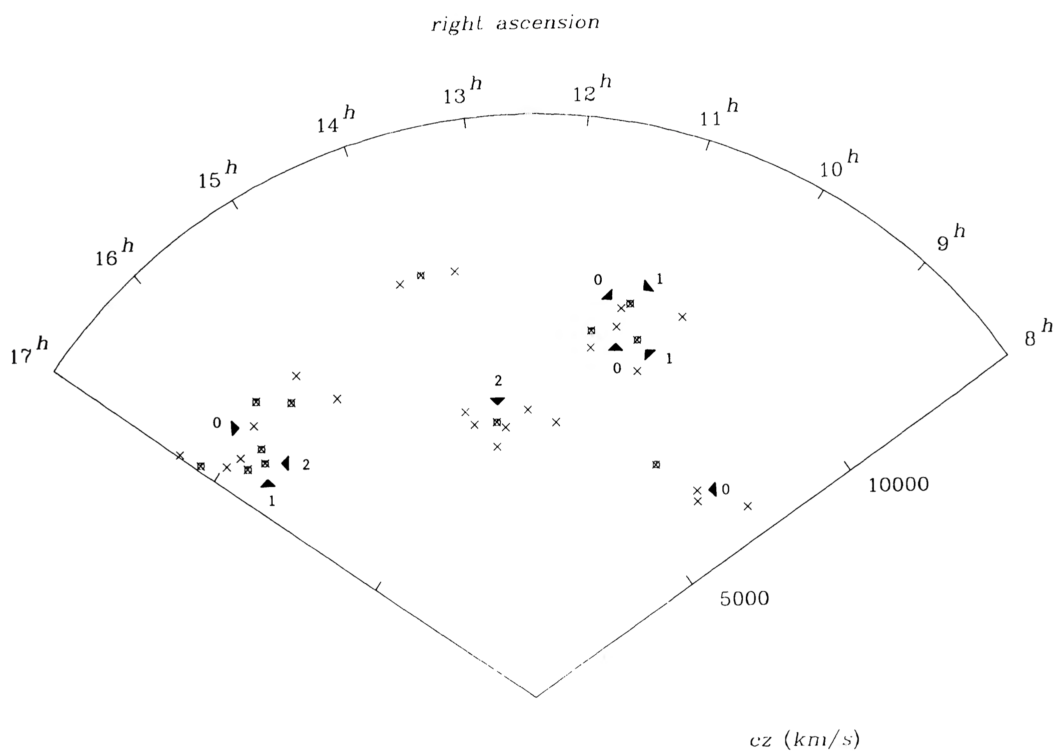

FIG. 7.—Cone diagram (18° slice) for "cluster-like" groups: (a) R = 0 (crosses) (b) R ≥ 1 (circles). Arrows mark Abell clusters; the numbers near the arrows are Abell's richness classification for each cluster.

shift space appears to support the reliability of Zwicky's cluster catalog for nearby systems. Furthermore the Postman *et al.* (1986) correlation length for Zwicky clusters which are spread over a larger area of the sky strengthens our finding that groups have a correlation function consistent with ξ_{gg}.

BS83 discuss the decrease of the cluster correlation function amplitude, ξ_{CC} (1 Mpc) with richness. They also classify individual galaxies as $N = 1$ *systems* (where N is Abell's (1958) criterion for richness classification) and suggest that galaxies have a correlation function amplitude which falls on the richness relation for clusters. From a physical perspective, it is probably misleading to treat individual galaxies this way. The processes which govern galaxy formation differ from those important for systems.

The clustering of groups does appear to be consistent with the scale-invariant clustering of richer systems (Bahcall and Burgett 1986). We find that the group correlation function ξ_{GG} has the same correlation length as ξ_{gg}. It is not possible to translate the number of members of our groups into a specific N. However, because many of the richest groups are nearby Zwicky clusters, N for all groups must be less than or equal to that for nearby Zwicky clusters. For any $N \lesssim 10$ the richness dependence of the correlation amplitude applies to all *galaxy systems* but *not* to *individual galaxies.*

Consistent with this argument, SS85 pointed out that galaxy-clustering might be intrinsically different from cluster-clustering. They discuss a possible "universal" correlation function for clusters characterized by a slope -1.8 and by a dimensionless amplitude β. This amplitude is obtained by scaling ξ(1 Mpc) with the mean separation between systems, $L = n^{-1/3}$. SS85 derive $\beta \simeq 0.35$ for Shectman's (1985) clusters and for Abell $R \geq 1$ and $R \geq 2$ clusters. For galaxies they obtain $\beta = 1.1$. This value is significantly higher than for clusters and, within this picture, would mean that galaxies are relatively more strongly correlated than clusters.

Now we investigate whether groups obey the scaling suggested by SS85. The best fit slope for ξ_{GG} is -1, but -1.8 cannot be ruled out. To derive the value of β for our sample of groups we need the space density, n_G. To estimate n_G, we use the density of clusters scaled by the ratio of the number of groups to that of Abell clusters in our survey. There are five Abell clusters with $R = 1$, 2 and 173 groups: for a density of clusters $n_C = 6 \times 10^{-6}$ Mpc^{-3} ($R \geq 1$; BS83) we obtain $\beta = 0.2$. This value is in reasonable agreement with $\beta = 0.35$, given the uncertainties in both the density and the correlation function. We find even better agreement with SS85 if we use Schectman's (1985) density, $n_C = 3.6 \times 10^{-5}$ Mpc^{-3}, and scale it according to the number of $R \geq 1$ "cluster-like" groups in our survey. We derive $\beta = 0.3$. It is interesting that Shectman's (1985) density predicts 12 clusters in the volume of our survey, i.e. the number of "cluster-like" groups. For $n_C = 6 \times 10^{-6}$ Mpc^{-3} (BS83), we expect only two clusters with $R \geq 1$. In summary, the amplitude of the group correlation function is consistent with an extrapolation of the amplitude-richness relation and with the density scaling found for richer systems.

V. DISCUSSION

The group correlation function ξ_{GG} indicates that, to within the errors, groups and individual galaxies are equivalent tracers of the large-scale matter distribution. Because ξ_{GG} and ξ_{gg} are indistinguishable, the distribution of group centers is equivalent to random sampling of the galaxy distribution. Inspection of the cone diagrams in Figures 1*b* and 1*c* should convince even the skeptic that groups trace the large-scale structure marked by individual galaxies.

We do not understand the source of the discrepancy between our results and those of Jing and Zhang (1988) or Maia and da Costa (1989). We suspect that the $V_0 = 600$ km s^{-1} used for their group catalogs may be part of the problem. As emphasized by Nolthenius and White (1987) in evaluating Geller and Huchra (1983), this velocity cut admits too many interlopers.

There is no direct observational evidence that richer clusters are reliable tracers of large-scale structure. Such evidence could only be derived by comparing the distribution of rich clusters and galaxies *within the same survey*. Redshift surveys are not yet large enough to permit such a comparison.

Although our statistical confidence in the identification of a particular poor group may be low, the group catalog is extracted from the redshift survey by a completely objective, well-defined procedure. Exactly the same procedure could be applied to an N-body simulation (see, e.g., Nolthenius and White 1987). To test the models against the data one could compare not only the group correlation function ξ_{GG} but also the behavior of the correlation functions for "members" and the "field."

The amplitude of the correlation function for groups is consistent with an extrapolation of the amplitude-richness relation for clusters (Bahcall 1988). The amplitude scaled by the mean intersystem separation is also consistent with results for richer clusters. We suggest that these two results are flip sides of the same coin: they reflect the scale free nature of cluster clustering (Szalay and Schramm 1985). We also suggest that the clustering of *individual galaxies* is an *exception* to both the amplitude-richness relation and the density scaling.

One of the difficulties in comparing results for groups and clusters is the fundamental difference in the way the catalogs are constructed. Redshift surveys are not yet large enough by themselves to extract samples of rich systems. Furthermore, the richness parameter is not ideal for describing the systems selected from complete surveys. Velocity dispersion, central density, or mass (see Kashlinsky 1989) are parameters more closely tied to the physics of the systems. Eventually redshift surveys will be large enough to investigate the amplitude-richness relation (or its equivalent) in an internally consistent way.

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