CHAPTER IV

THE LARGE SCALE DISTRIBUTION OF GALAXIES

https://doi.org/10.1017/S0074180900159236 Published online by Cambridge University Press

THE DISTRIBUTION OF BRIGHT GALAXIES

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ABSTRACT Following a brief review of the early developments in the field, we discuss a few new advances in the distribution of bright galaxies which occured after the extensive review paper by Oort (1983) We show that the large scale structure, shells, filaments and/or sheets, may bias the determination of the velocity dispersion in clusters of galaxies and that the boundaries of the voids may often be biassed by the clusters and groups velocity dispersion.

Of interest are the very large structures selected on catalogs of clusters of galaxies. The "Local Structure" claimed by Tully seems to be somewhat flattened and about parallel to the plane of the Local Supercluster. If the structure is real the alignement is relevant in relation to the physical mechanisms at work at the time of formation. Noticeable progress has been done in the measurement of the large scale velocity field. Large scale motions may somewhat bias the study of the topology of the Universe.

Relevant work has be done on the shape of the boundaries of the voids and observational work is progressing to detect faint galaxies in voids and determine their charactestics. This is important also in relation to the theory of biassed galaxy formation. To better focus the observational problem and eventually related biasses, we give some statistics on dwarf galaxies in the Virgo cluster.

1. INTRODUCTION

The study of our environment, the Cosmos, dates back to the time the human being took consciousness of himself and of its surroundings. The increase of scientifical knowledge and technology expanded, during the centuries of our evolution, the orizon of the physical world.

In most modern times and after the theoretical work on cosmological models it became clear that the knowledge of the distribution of galaxies, taken by most scientists as a mark of the distribution of matter in the Universe, would let us understand not only the present status of the Universe, but also give us some observational data to be used as test for models about the origin and evolution of the Universe as a whole.

A. Hewitt et al. (eds.), Observational Cosmology, 275–300.

In the last few years a lot has been written on the large scale structures and varius review papers have been published, e.g. among others Chincarini (1982) and the comprehensive review by Oort (1983). We will therefore only schetch some of the early development and focus our attention on some of the recent work which we believe particularly important.

Sandage (these proceedings) mentioned that in the data of Hubble (1936) we already have the notion of clustering. Shapley and his collaborators (e.g. Shapley and Ames, 1932; Shapley, 1935) , however, pioneered the two fundamental aspects of the large scale distribution of galaxies. They called attention to the existence of a local large scale structure, the Local Supercluster, and detected other distant structures

Later and in a different form Abell (1958) and Zwicky (e.g. Zwicky, 1957) called attention on other agglomerates and it became fairly clear that not only the distribution of galaxies is clumpy but that also the distribution of clusters of galaxies is not random (Abell 1961).

De Vaucouleurs (1958) is probably the one who had an early understanding on the significance of Shapley's work on the local distribution of galaxies and devoted important years of research in understanding this structure.

Shane and Wirtanen (1967) undertook a monumental observational work in a very accurate survey on the distribution of galaxies while Neymann and Scott (see e.g. their 1959 review) developed foundamental statistical tools to allow their interpretation.

The discovery of the microwave background (Penzias and Wilson 1965 and Dicke et al, 1965) gave confidence to a theoretical framework around which to develop numerical models and marked the birthday of the observational cosmology in all its branches and complexity.

In the early seventies Peebles and collaborators (see Peebles 1980) were heavily involved in developing the autocorrelation function machinery and in using it to understand the large scale clustering using two dimensional catalogs. Earlier a pioneer analysis of the Shane-Wirtanen catalog was carried out by Totsuji and Kihara (1969).

In the same period it became feasible, thanks to the new image intensifiers and availability of telescopes, to observe a fair number of redshifts of galaxies in a reasonable amount of time. It is worth stressing that good telescopes in good sites and with advanced instrumentation always allow good progress in research. This may be important for those countries which plan a growth in observational Astronomy.

The availability of the redshifts opened the way to the 3-dimensional studies of the distribution of galaxies.

Chincarini and Rood (1975) in the attempt to determine the size of the Coma cluster, following also discussion and suggestions given by Zwicky, realized that galaxies at the redshift of Coma were still present at very large angular distances from the cluster itself. Chincarini and Martins (1975) in the attempt to explain the discrepant redshift in the Seyfert Sextet realized that the distribution of galaxies in the redshift space was not homogeneous. Redshifts were indeed segregate. In other words regions populated by galaxies were separated by regions empty of galaxies.

The large scale clustering found in the redshift surveys was found to be in very good agreement with the picture that Peebles and collaborators were deriving by measuring the autocorrelation function of galaxies using two dimensional distribution of galaxies as listed in various catalogues: Shane and Wirtanen, Zwicky and the Jagellonian field (see Peebles 1980).

It is in this period and following also the work of Gregory et al (1981) that it became clear that in the Universe we had large scale structures and large regions void of galaxies. Independently this line of research was persued by Einasto and his collaborators (e.g. Einasto et al, 1980)). Fundamental in this context has been the theoretical work developed by Zeldovich and his collaborators (see e.g. Zeldovich, 1978).

In the early eighties enough observational and theoretical work had been done to allow an extensive meeting on this and related topics, IAU Symposium 104. The coupling between the very early Universe, related high energy physics and the observed distribution of matter was already in full development

The distribution of galaxies is not an isolated subject. It is related to the study of perturbations in the density and velocity field, to the formation and evolution of structures and galaxies, to the understanding of cluster membership, to phenomena of interaction between galaxies and the intergalactic gas, and deeply connected to the problematic of the missing mass (and its distribution).

In this review we will limit ourselves to the disribution of galaxies and refer for the rest to the various reviews and specialized papers presented at the present symposium. While M. Geller will discuss the recent results of the Cfa survey, we remind that in addition to the other large survey carried out at Arecibo, work is progressing in Brasil and South Africa. The work done in Soviet Union will be illustrated by Karachentsev.

2. SUPERCLUSTERING

The basic assumption here is that, in first approximation, the redshift is a measure of distance. We also refer to a large scale structure or a supercluster meaning an agglomerate of galaxies or systems which show a certain connection, and detected either by a percolation algorithm or visual inspection.

These assumptions are reasonable, however they also reflect the limits of our findings. Large scale motions would distort the topology (large peculiar velocities in clusters are easily recognizable) and the size and the form of a structure will depend on the length of the percolation vector or equivalently the density contrast over the mean. The volume of the sample itself will limit the size of the structures which can be detected.

Finally, as it has been often mentioned, the word "supercluster" means different things for different people and the word "filament" is, at times, improperly used.

The region of Coma has always been one of the most studied regions of the sky. It is of some interest, therefore, to compare the distribution as published by Chincarini and Rood (1975) about 10 years ago, Figure 1, with a compilation made by Gavazzi (1986), Figure 2. In addition to the published redshifts, in the plot are included about 110 new redshifts obtained at Arecibo. The richness of details, structures and clustering and the improvement over the years is remarkable.

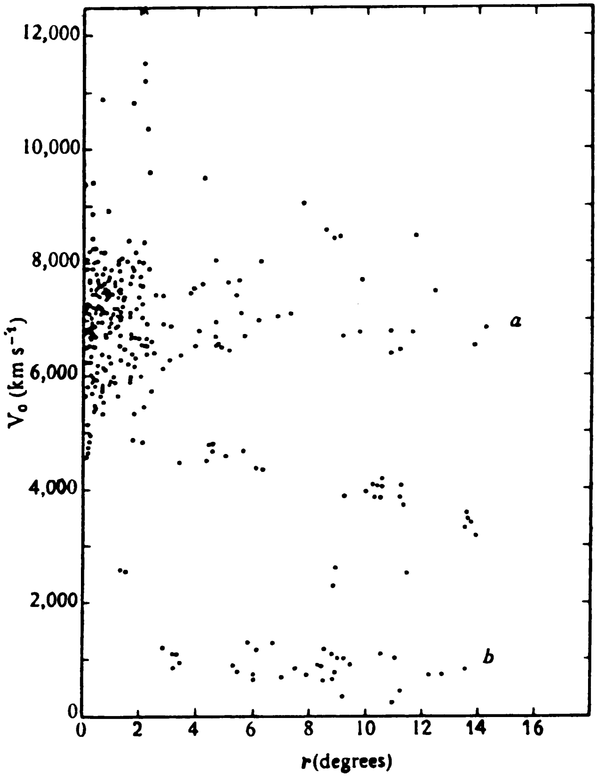

Figure 1. The distribution of galaxies in the Coma region, Chincarini and Rood (1975).

In this contest we show in Figure 3 the velocity histogram prepared about ten years ago according to the compilation of redshifts in Coma by Gregory and Thompson (1978). Statistically we cannot distinguish between 1 or 2 gaussian fittings. Gavazzi (1986) independently finds the same thing , Figure 4. The two gaussian interpretation has now an higher significance, however not so much because of statistics, but mainly because of the fact that part of a filament (or pseudo-shell) may

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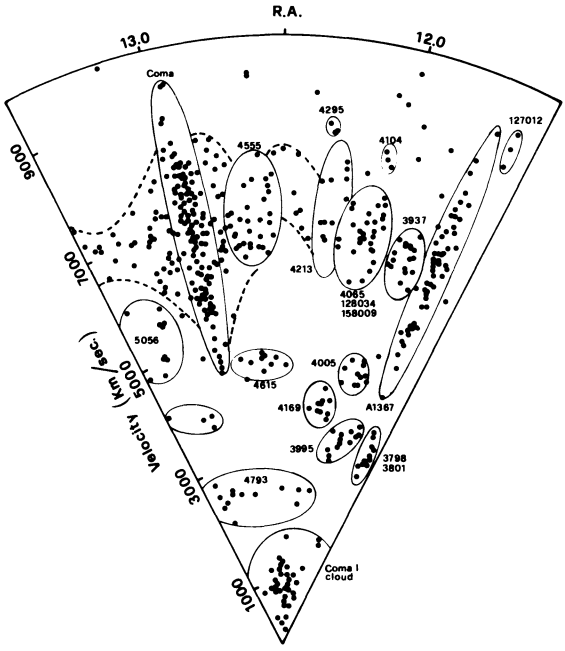

Figure 2. The distribution of galaxies in Coma as prepared by Gavazzi (1986). In the plot we have 570 redshifts most of which are from the literature. 110 redshifts from Arecibo are unpublished.

be located in front of the cluster proper, Figure 5 left. The filament is visible, with various extension, also in the deep survey by de Lapparent et al (1986), Figure 6. Such an interpretation would decrease the velocity dispersion of the Coma cluster of about a factor 1.43 and the mass of about a factor 2.

Comparison of Figure 5 left with Figure 5 center and right shows that the void boundaries so sharply defined in the first are poorly visible in the other two figures. The western wall is well defined only in Figure 5. left because of the compression in declination and it is largely due to the effect of the velocity dispersion in the cluster A1367. It is a flag of caution.

The well observed structures in the Perseus-Pisces region (Giovanelli et al, 1986) and Hydra-Centaurus (da Costa et al 1986a, 1986b) are displayed in Figures 7, 8 and 9.

Figure 8 has been obtained using a percolation algorithm on the two dimensional distribution of galaxies of the ESO-Uppsala Catalogue (Lauberts 1982). The Hydra structure seems, unless we go to very low

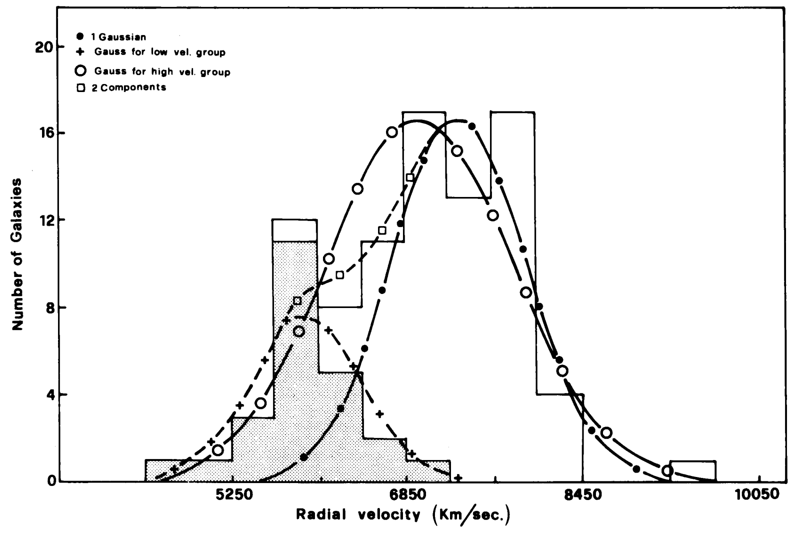

Figure 3. Histogram of the redshifts for the Coma cluster as plotted in 1979 (according to the data listed in Gregory and Thompson 1978)

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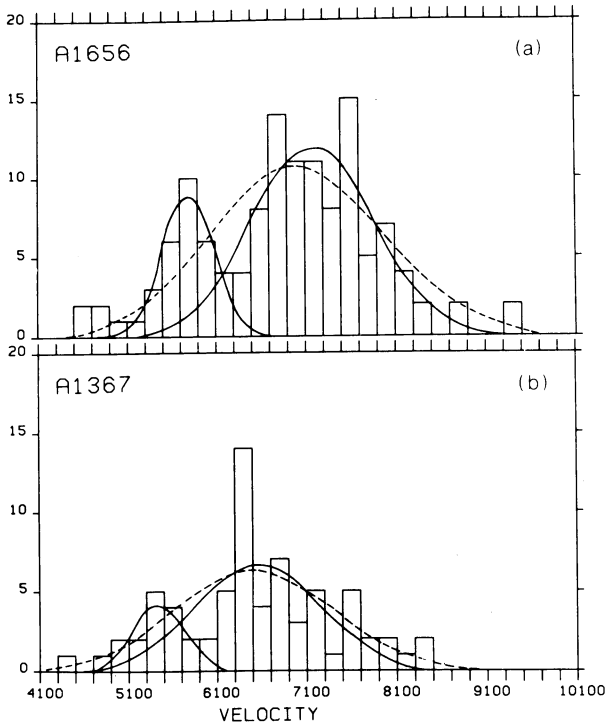

Figure 4. a) Redshifts histogram (128 galaxies) of a 4 square digrees region centered on the Coma cluster. b) the same for A1367.

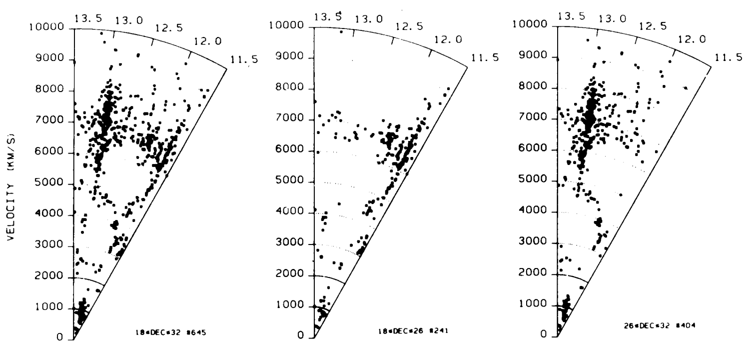

Figure 5. Left: wedge diagram of 465 galaxies in the region of Coma. Note the filament at about V = 5800 Km/sec forming the boundary of a void and located in front of the cluster. Center and right: the two different cuts in declination show that the structure of the void is irregular and/or that the cluster velocity dispersion (A1367) may simulate in part the void boundary.

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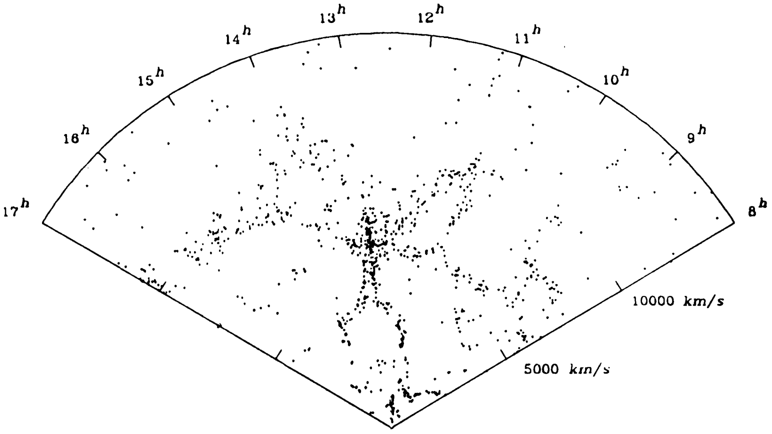

Figure 6. The distribution of galaxies in the region of Coma between 26:30 and 32:30 degrees in declination, according to the data of de Lapparent et al (1986).

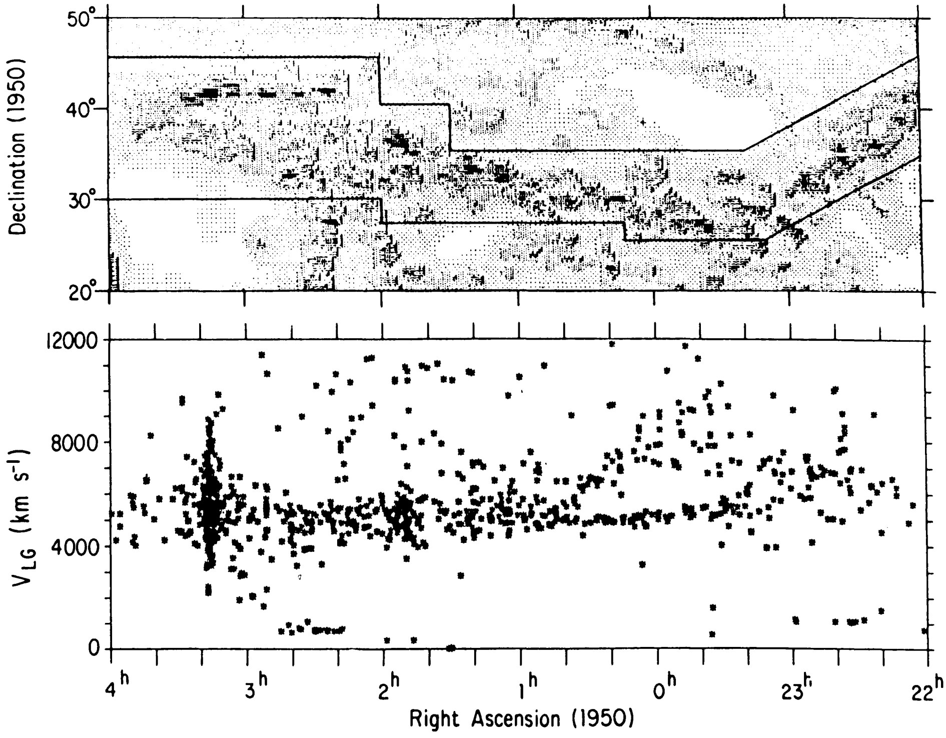

Figure 7. The Perseus-Pisces supercluster. Top: the density distribution of galaxies as seen projected on the celestial sphere. Bottom: The distribution of galaxies in depth (redshift).

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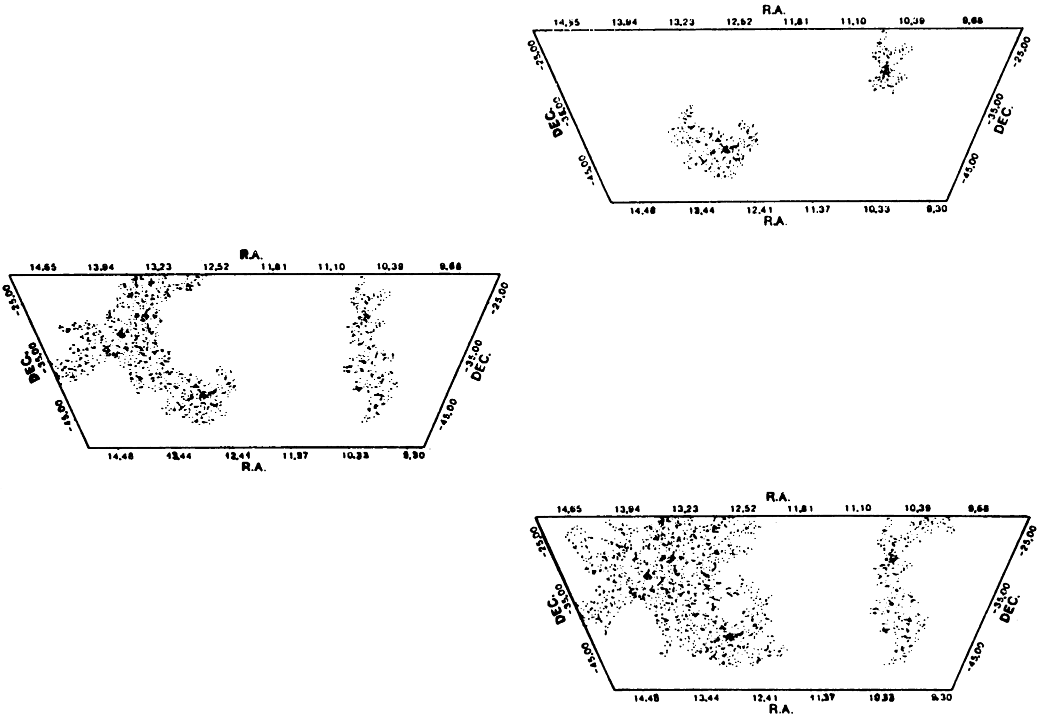

Figure 8. The Hydra-Centaurus structure as a function of the percolation vector. The percolation vector increases from the figure at the top to the figure at the bottom right (0.77, 0.80, 0.89 degrees). Note the lack of galaxies in the region between 11 and 12 hours in R.A.

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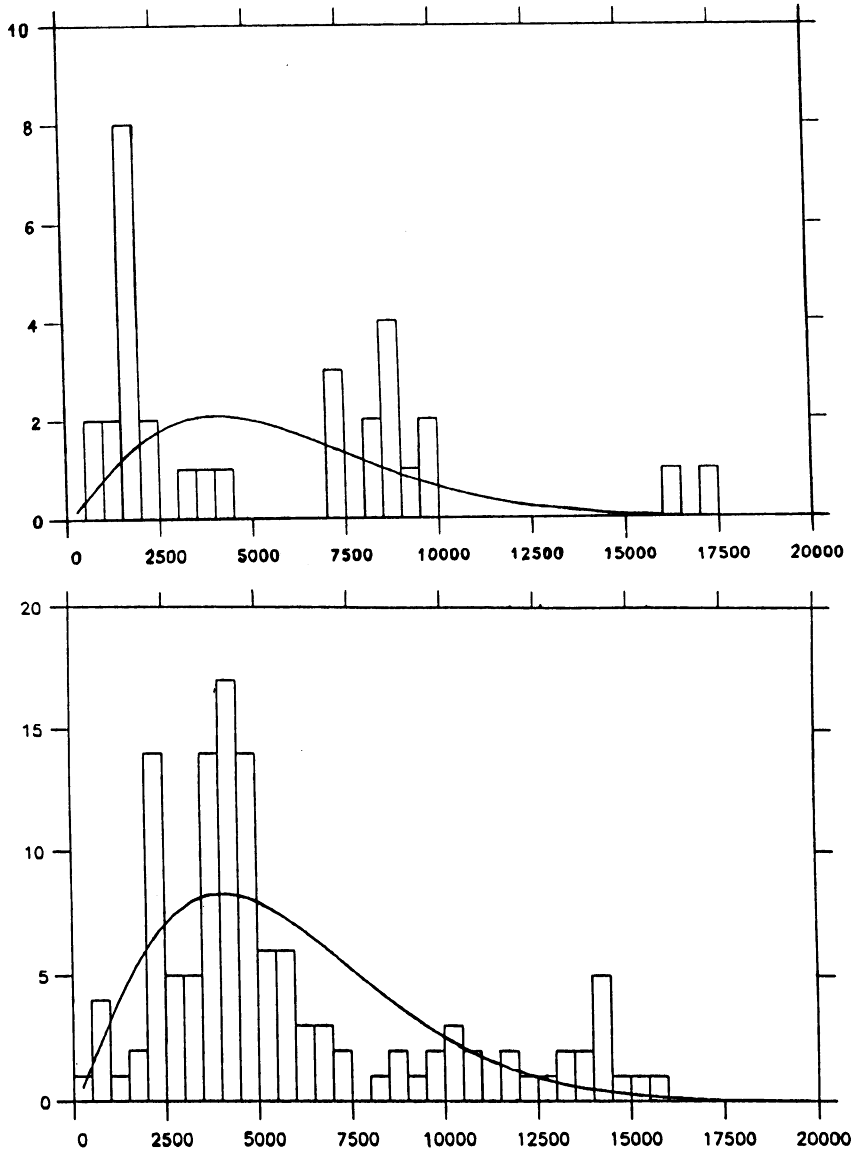

Figure 9. The region Hydrae-Centauri. Top: redshift distribution in the two dimensional gap between Hydra and Centaurus (see Figure 8) from 11 to 12 hours in R.A. and -27 -33 degrees in declination. Bottom: redshift distribution in Centaurus: $13^h \leqslant$ R.A. $\leqslant 14^h$ and $-33^\circ \leqslant$ DEC $\leqslant -25^\circ$.

density levels, disconnected from the Centaurus supercluster. To test for this effect redshifts were obtained in the region between 13 and 14 hours in R.A. and between -25 and -33 degrees in declination. The comparison between Figure 9 top and Figure 9 bottom clearly shows that there is a lack of galaxies with the redshift of Hydra-Centaurus (Da Costa et al 1986 b).

Since the mechanism of formation may have determined the present shape of superclusters it became important to determine some structural parameters to ease the comparison between observations and models. Doubts on disk shaped structures have been expressed by Oort (1983) and Chincarini (1982) and it seems that at least in the Perseus-Pisces supercluster there is some evidence of a filamentary structure.

The uncertainty on this matter is clearly apparent from a statement by Oort (1983) in his review article, when he discusses the central structure of Virgo:

" ..... it may either be an oblate distribution seen roughly edge-on, or possibly a prolate feature"

An analysis of shape parameters has been carried out on a complete sample with $m \leqslant 14.5$ by Chincarini et al (1986), see Vettolani et al (this conference).

A very puzzling possibility is the existence of agglomerates which exceed by a rather large factor the superclustering scale so far proposed. That we have continuity or connection among clusters and superclusters at very low galaxian density is a rather old concept and indications were available since some time. What is new, and very important if the reality can be confirmed, is that such connection and related agglomerates form a very large scale structure having some physical significance of its own. In other words it may be a larger unit cell in the Universe.

We refer in particular to the large structure embedding the Local Supercluster indicated by Tully (1986). He suggests that the larger stratified and flattened structure extends in layers of about 400 Mpc. The main and richer layer would be in the plane of the supergalactic equator. The geometry is shown in Figure 10.

Is this a real fact or could it be due to an observational bias?

Some possible biases are the following:

a) The supergalactic plane is favored by galactic extinction because it is located toward the north galactic pole. We notice however that long ago de Vaucouleurs (1976) has given clear evidence that the plane of the Local Supercluster is not due to an effect of obscuration. It seems therefore that a bias due to galactic obscuration is unlikely also in this case.

b) The percolation algorithm, or any clustering algorithm, is favored in connecting structures across the zone of avoidance because of 1) galactic exctintion, 2) the presence of the boundaries defined by the zone of avoidance 3) the incompleteness of the sample.

That the cluster catalogs may be affected by not well known observational biases it seems suggested by the recent work of Shectman

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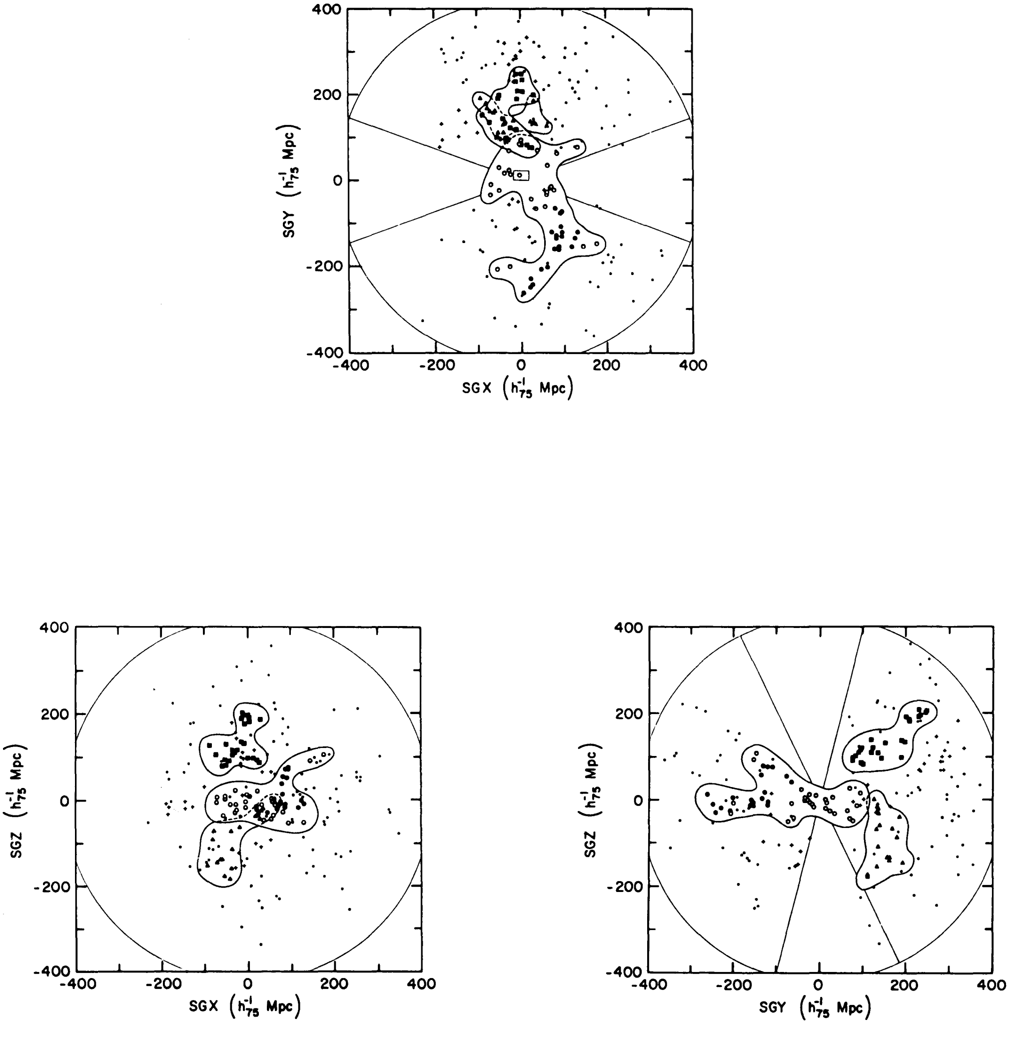

Figure 10. Distribution of clusters of galaxies according to Tully (1986). The supergalactic plane is Π(SGX,SGY).

(1985). The sample of clusters selected by Shectman from the Shane-Wirtanen galaxy counts shows that only 40% of these clusters are members of the Abell catalog. Shectman, furthermore, calls attention to an unexplained absence of clusters north of declination 57 degrees and to a lack of clusters in the range of galactic latitude between 40 and 50 degrees.

The evidence can be enforced or weakened only by future work, simulations and observations, and by complete and deeper samples. Some of the uncertainties will be probably resolved with the completion of the southern catalogue of clusters of galaxies, Abell, Corwin and Olowin (1987).

Assuming however that these structures are real and not due to an unknown observational bias, the important fact is not so much the size (we have other detections of large clusters of clusters) but the fact that the main plane of the structure is about parallel to the plane of the Local Supercluster. This calls for physical phenomena at the time of formation. Large scale clustering, up to 300 h Mpc has been evidenced by Batusky and Burns (1985a and 1985b), Bahcall and Soneira (1984), Bahcall and Burgett (1986). Indeed Abell (1961) in his analysis on the clustering of clusters gives an upper limit of about 1000 Mpc. He clearly stated that the distribution of clusters of galaxies is non-random.

Bahcall and Soneira (1983) put this fact on a very solid basis showing that the spatial correlation function of rich clusters of galaxies (Abell's catalogue) is approximately 18 times stronger than the correlation function of galaxies.

What is also attractive is the simple explanation given by Bahcall (1986). This is the quantized version of the simple minded observational fact which has been often stated: clusters are embebbed in larger structures.

Perturbations in density are necessarly related to perturbations in the Hubble flow so that large scale motions must be considered. These must ultimately be in agreement with the dipole anisotropy observed in the microwave background.

Fair understanding has been gained on the perturbations caused by the Virgo supercluster (for a comprehensive discussion on this matter see Tammann and Sandage 1985) while large uncertainties remain on larger scale motion.

The latest attempt in clarifiyng this matter is the work by Burstein et al (1986). Using the magnitude related parameter D_Σ , the diameter within which an elliptical galaxy reaches a mean surface brightness of 20.75 B mag arcsec^{-2} , and the relation $D_\Sigma - \sigma$ (σ is a measure of central velocity dispersion) the authors are able to predict distances to individual galaxies with accuracies of $\pm$ 23 %. With this new distance indicator and the accurate redshifts they interpret the observed systematic deviations from the Hubble flow as due to a bulk motion of approximately 700 km/s towards l =299 and b = 1 degrees for galaxies within 60 h^{-1} Mpc of the Local Group, see Fig 11.

The detected motion is in agreement with the motion derived using

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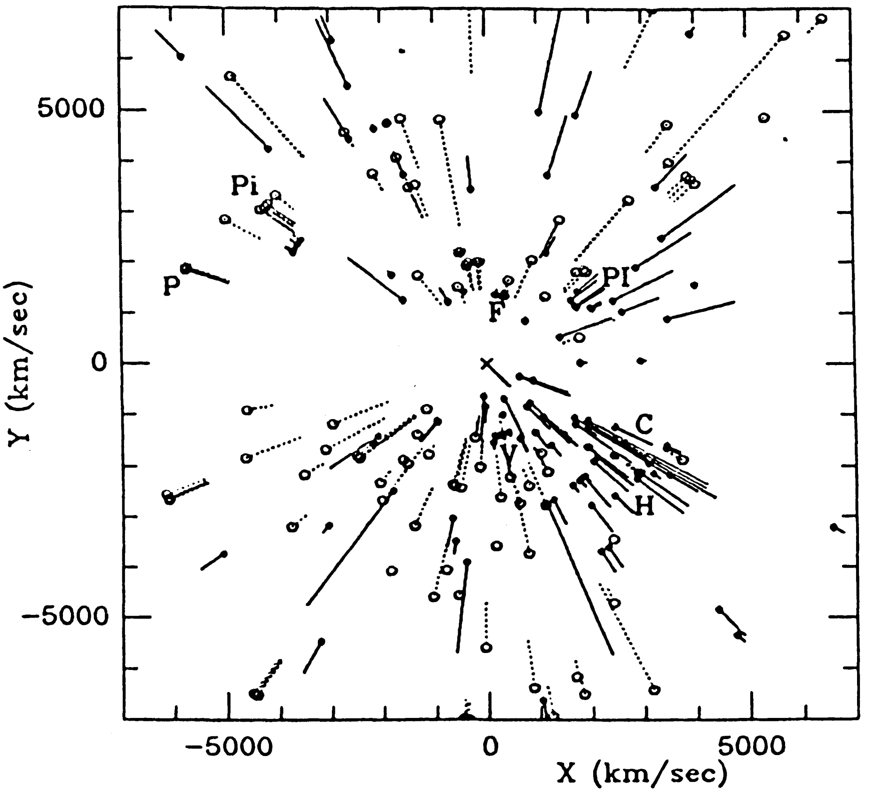

Figure 11. Motions of elliptical galaxies (Burstein et al 1986) with respect to the microwave background reference frame. The peculiar motion is represented as a solid line for a velocity vector pointing away from the position of the Local Group and as a dashed line for a velocity vector pointing towards the Local Group.

other samples, that is the sample of spirals by Aarson et al (1982), via the infrared Tully Fisher relation, and the Rubin-Ford sample (Rubin et al 1976)

Bahcall et al (1986 and these proceedings) using a complete sample of clusters of galaxies (subsample selected from the Abell Catalogue with $D \leqslant 4$ ($z \leqslant 0.1$) and $R \geqslant 1$) detect a strong asymmetry in the space distribution of cluster pairs. The strong elongation observed in the redshift direction corresponds to a velocity broadening of about 2000 km/s among clusters pairs.

The phenomenon, which appears to be real, is interpreted as partly due to the geometrical elongation of the superclusters along the line of sight. Peculiar velocities, on the other hand, could play a large role.

With the present data it is impossible to disentangle or distinguish between the two effects. Only in one case, the Hercules supercluster is a clean magnitude redshift relation which shows that cluster members satisfy the Hubble relation and are endeed spread along the line of sight.

It is unlikely, however, that the superclusters considered could be in equilibrium and that the velocity could be interpreted as due to a balance between kinetic energy and the gravitational potential energy. It seems more likely that such motions reflect perturbations in the Hubble flow due to overdensities or mass motions involving large volumes of space and reflecting primordial perturbations.

Infact the large scale motions discussed by Burstein et al (1986), and previously by Rubin et al (1976), the infall to Virgo and the dispersion detected by Bahcall et al (1986) are probably all due the same mechanism. A dispersion of about 2000 km/s on a scale of about 25 h^{-1} Mpc seems, however, rather large.

3. VOIDS

Recently attention has been focussed particularly on the regions of space which are void of galaxies, the "voids".

After Chincarini and Martins (1975), Chincarini and Rood (1975), Gregory and Thompson (1978), Tifft and Gregory (1978), Tarenghi et al (1979) clearly showed that on large scale galaxian redshifts were segregated in rather well defined intervals, a distribution structure-void, it became clear that such empty regions could help in distinguishing among clustering models.

The detection by Kirshner et al (1981) of a rather large void in Bootis convinced many of us that a pancake scenario, and related galaxy formation and evolution, could be the most likely explanation of the observed distribution of galaxies.

Vettolani et al (1985) approached the problem statistically using a sample complete to $m \leqslant 14.5$. In this study they came to the conclusion that 1) the voids observed in the sample used do not contradict a hierarchical distribution of matter in the Universe and 2) the presence of large voids as the one detected in Bootes could be explained in a hierarchical realization.

Soltan (1985) analyzed a similar sample, in this case a subsample of the Cfa redshift survey (Huchra et al 1982) with $M \leqslant -20.5$. As stated in Vettolani et al (1985) it is a matter of whether it is more reliable a sample with larger statistics and somewhat more complicated analysis or a sample with small statistics and a rather well defined volume. In practice Soltan (1985) reaches the same conclusions reached by Vettolani et al (1985) . If this is the case, voids could be a result of the gravitational clustering process and there is no need to invoke a special mechanism producing voids in the galaxy distribution: these form as a consequence of the clustering process.

However, using the wording by Occhionero et al (1984) it is a matter to decide whether we are dealing with condensations surrounded by cavities or with cavities surrounded by condensations.

Ikeuchi et al (1983) and Ostriker and Cowie (1981) propose that galaxies, and related structures, form in an intergalactic medium dominated by explosions. In this case the structures, rather than the voids, came second.

De Lapparent et al (1986), Fig. 6, claim that the distribution of galaxies observed in their sample ($m \leqslant 15.5$), a 6 times 117 degrees strip (0.2138 steradians) going through the Coma cluster, appears to have a bubble like structure with the galaxies distributed on the surface of the bubble. The bubbles have, according to the authors, a typical diameter of 25 h^{-1} Mpc, R 12.5 h^{-1} Mpc. Another striking feature emphasized by the authors is the sharpness of the boundaries of the high density regions which surround the voids (see Geller, these proceedings).

Statistics on voids, as we said, is rather scarce since a good understanding can be obtained only with deep samples, m 14.5, over large regions of the sky.

Using the zero order approximation given in Vettolani et al (1985) the number of voids of a given volume expressed in units of V_o , the volume of the sweeping vector (V_o = 7^3), is

$$N_{14.5}(V/V_o) = 3/2 (V/V_o) \qquad N_T (14.5)$$

and the corresponding probability is

$$P(\geqslant V/V_o) = 3/2 \int N \quad (V/V_o) =$$

$$3/2N_T (14.5) (V/V_o)$$

Therefore, for the de Lapparent et al (1986) sample we find

$$N_{15.5} = N_{14.5} * V_{15.5}/V_{14.5} = 3.98 * N_{14.5}$$

where the volume of the sample has been increased by the amount

$$V_{15.5} \;/V_{14.5} = 10^{3/5(15.5-14.5)} = 3.98$$

with N_T $(\leqslant 14.5) \simeq 100$ over 4 sterad (Vettolani et al 1985) we derive

N = 43.9

The number of fields equivalent to the de Lapparent et al (1986) field in 4 steradians is 4 / 0.2138 = 18.71 and the number of expected 25 h^{-1} Mpc diameter voids is 43.9 / 18.7 = 2.3, a sizable number even if computed in a zero order approximation.

The number of voids observed in the de Lappàrent et al (1986) sample is about 4. The approximate dimensions and volume as derived from their Figure 1 is shown in Table I.

Table I

void	V	V	Volume
	km/s	km/s	10 Mpc
1	3000	1590	31.6
2	8000	2400	19.3
3	7900	2170	160.0
4	9200	2000	23.7

If the topology of these large structures is confirmed and the number of rather large voids increases when compared to the simple hierarchical distribution of galaxies it may be hard to avoid the conclusion that standard gravitational clustering models do not match the observations.

While a bubble like structure may be somewhat unlikely, it seems that a sponge like structure is in agreement with most of the observations (see Gott, these proceedings). The data will show which one the Universe preferred. See however Ruffini (these proceedings) for another interpretation.

At the voids boundary we expect, both in the case of a hierarchy generated by gravitational phenomena and in the presence of cavities surrounded by superclusters (bubbles and shells) a galaxian density enhancement, Hoffmann et al (1983) (1983), Occhionero et al (1983), Peebles (1982) and Ostriker and Cowie (1981).

While de Lapparent et al (1986) find some indication of overdensity on the ridges, Soltan (1985), in a sample limited however at 14.5, but with a much larger volume, states that his analysis shows that galaxies do not create high-density regions around the voids. Any evidence on this is rather scanty also in view of the fact that one has to be carefull about the subtle effect of the velocity dispersion in groups and clusters, compare Fig. 2 with Fig. 12, where we have marked the presence of two groups. The alignment of the void wall, in the direction of the line of sight, is partly due to the velocity dispersion of the member galaxies. To better understand this and other problems related to the detailed structure of superclusters, via the Tully-Fisher relation we started years ago observations in the 21 cm line and infrared (H band, Gornengrat and KPNO).

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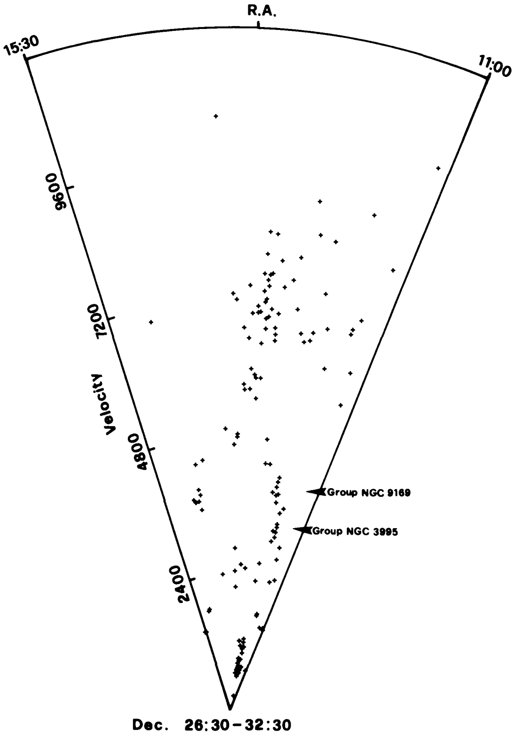

Figure 12. Galaxies in the Coma region with $m \leqslant 14.5$ and declination between 26:30 and 32:30 degrees. The figure shows how velocity dispersion in galaxies which are members of a group may simulate a void boundary and complicate the understanding of the boundary density.

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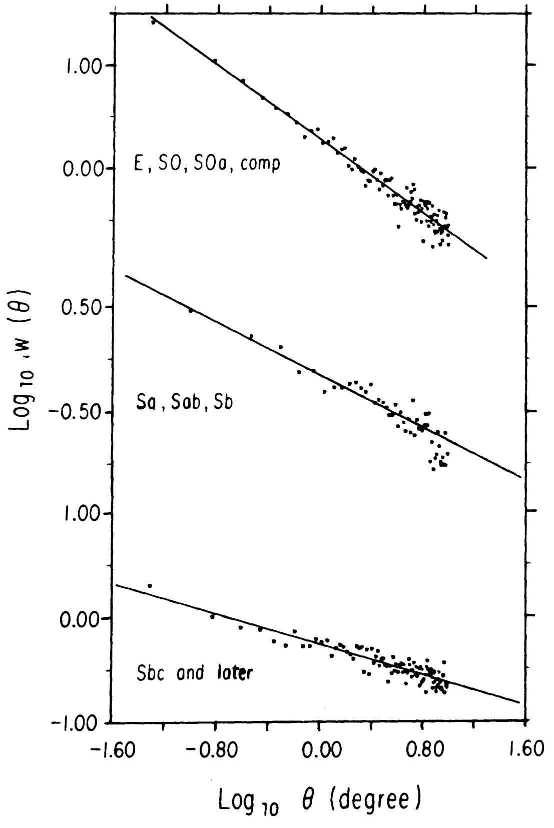

Figure 13. The autocorrelation function for various morphological types in the Perseus Pisces supercluster (Giovanelli et al 1986).

3. MORPHOLOGY OF GALAXIES AND STRUCTURES

Giovanelli, Haynes and Chincarini (1986), and references therein, have shown that the two points angular correlation function depends on the morphological type, Figure 13. That is late type galaxies are less clustered. Abell (1977) showed that it would be difficult to detect the Coma cluster by using solely spiral galaxies. In other words the more we go toward late types galaxies, the closer we approach a poissonian distribution.

The distribution of dwarf galaxies is known accurately only for the region of the Virgo cluster, Sandage et al (1984). The distribution of dE galaxies is somewhat clustered, Figure 14 left, while the irregular galaxies almost do not cluster at all. Indeed Sandage et al (1985) observe a lack of dwarf irregulars in the region of maximum concentration of dE galaxies. The result is confirmed, clustering of dE, by autocorrelating the sample of galaxies in Virgo.

The suggestion is that, unless we must distinguish between local and universal effects about the distribution of galaxies, the relation type-clustering strength holds down to the dwarf irregulars where any sign of clustering seems to be lost (note, however, that the sample is very small). Since dwarf galaxies are of low luminosity some correlation should be present also between clustering and magnitude.

Searching the literature we found 4 galaxies with magnitude $m > 14.5$ in the void of Figure 12. We did not, at present, a statistical search to check for the characteristics of faint galaxies in voids. In fact we do not have a good set of data, on the other hand we know that in other cases, Bootis void is one, going to fainter magnitudes we find a few faint galaxies in voids. The possibility is that dwarf galaxies may, to some extent, populate these regions of space and, perhaps, observationally support the idea of biassed galaxy formation.

However the question is: granted that we find some dwarf galaxies in the voids, are these galaxies located there because their formation is favoured by the low density region, whether or not dark matter is the solution to various cosmological problems, or because the distribution of dwarf galaxies does not show the clumpiness measured for bright galaxies. Virgo shows that regions of fairly high density of galaxies do not prevent the formation of dwarf galaxies. As for the type expected and number we must await for good data and for surveys similar to the one Binggeli (1985) is carrying out in non cluster fields.

To this end, however, it is of some interest to look at the distribution of types, diameters and surface brightness of dwarf galaxies in Virgo. Table II has been prepared using the data of Binggeli et al (1985). The surface brighness has been computed using the simple relation $SB = B + 5 \log D$ and at the distance of Virgo ($m-M = 31.7$) 20 arcsec correspond to about 2.1 Kpc. The sample incompleteness begins to be very strong at $SB = 25.5$ (Binggeli et al 1986). Note however that their definition of surface brightness is not simple minded as the one above. The low surface brightness and small

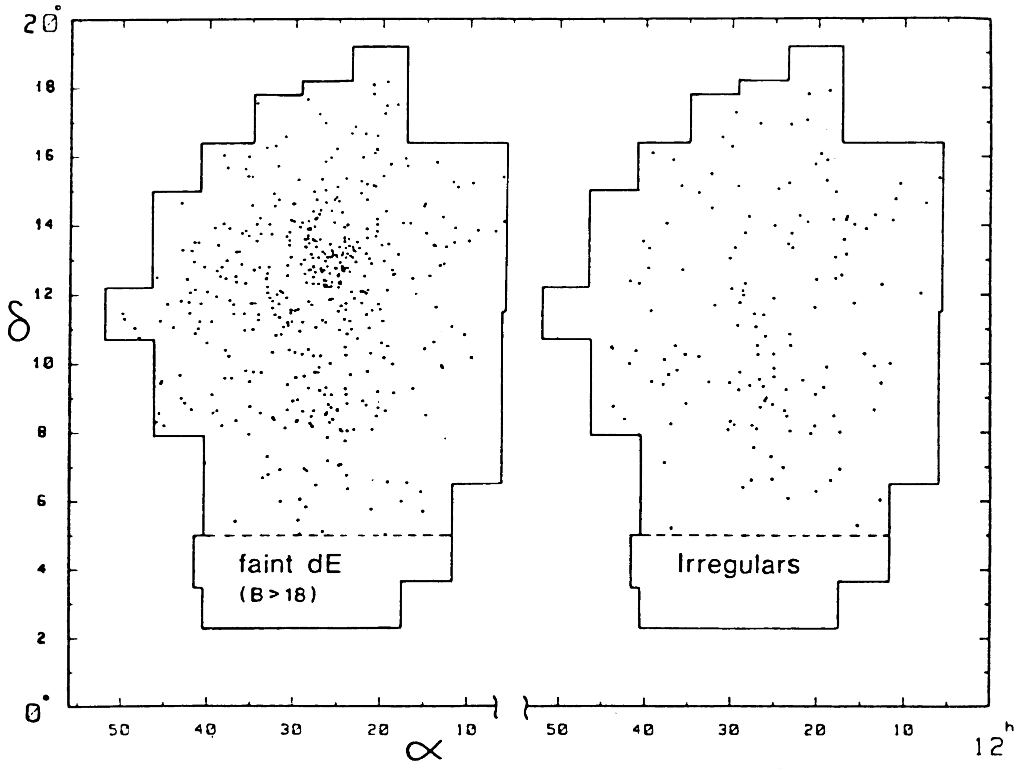

Figure 14. Distribution of dwarf elliptical and irregular galaxies in Virgo according to Sandage et al (1985).

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diameter make difficult the detection of the peak of the distribution.

Finally to estimate the expectation in the voids we have to account also for the correlation between dwarf type and density since dwarf ellipticals are more clustered than irregulars.

4. A CURIOSITY: MICRO-SUPERCLUSTERS

We find of some interest that structures similar to the one we observe on the large scale in the Universe are also seen on much smaller scale. We are familiar with colloids and areosols.

If we have particles of gold or nickel, with a diameter of the order of a few nanometers, in solution, the particles become ionized and repel each other. Such force dominates over the Van der Waals forces and the solution is rather stable against any form of aggregation. The repulsive electrostatic forces, however, can be shielded (or neutralized) so that the Van der Waals attractive force acts when the particles are close to each other and form aggregates. In other words the solution is now unstable toward aggregation. As it is well known when large aggregates form, the solution becomes opaque and the aggregates deposit to the bottom. In Figure 15 is shown the

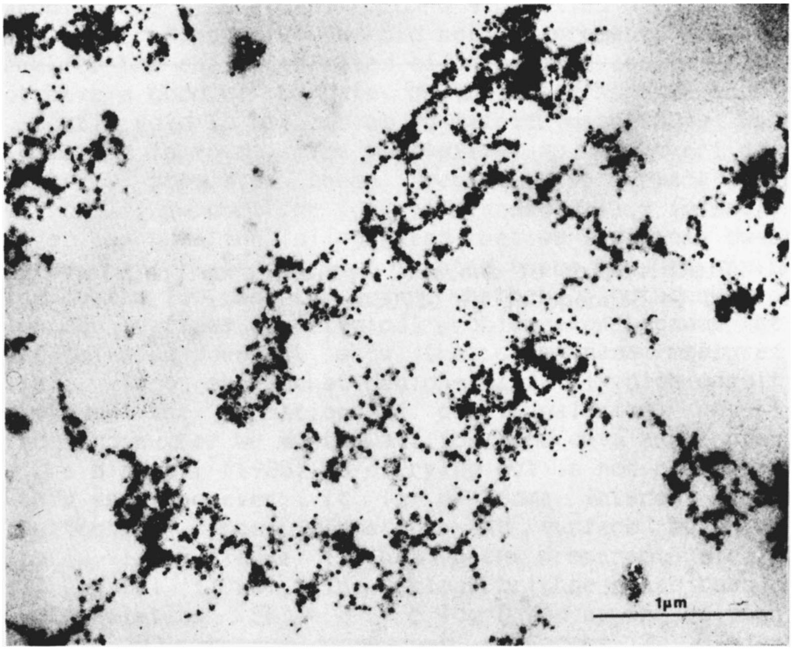

Figure 15. A microsupercluster: agglomeration generated in a nickel colloid. From Jullien et al (1985).

TABLE II

<SB>	dE	dS0	BCD	Im
19.5	0	0	0	0
20.5	0	1	0	0
21.5	2	8	0	0
22.5	12	20	1	4
23.5	127	18	16	14
24.5	395	9	17	60
25.5	453	6	6	51
26.5	147	0	3	18
27.5	11	0	1	0

<D> arcsec	dE	dS0	BCD	Im
20	411	1	21	21
25	282	0	16	24
35	204	2	12	23
45	87	8	6	18
55	71	3	4	16
65	31	1	2	13
75	21	6	1	8
85	15	7	0	13
95	8	3	0	3
110	12	2	0	3
130	5	12	0	5

reproduction of an aggregate of a colloid of Nickel prepared at Orsay by Mrs Belloni and J.L. Marignien and photographed with the electron microscope by J. P. Chevalier at Vitry (Jullien et al 1985).

The similarities with the distribution of galaxies on large scale is evident in spite of the fact that in this case the structures are somewhat more compact and large spaces exist among agglomerates. Are we learning something?

We do not want to push the similarity too far, but stress that also in this case we are dealing with fractals whose characteristics can be studied using the developments of Mandelbrot and the structures may be interpreted in a hierarchical model (see figure on page 1337 of Julien et al 1985).

This is an example of similarities between the micro and macrocosmos where similar structures are formed by forces of different nature.

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DISCUSSION

BURNS: Is there anything unusual about the galaxies at ~3600 km/sec that fall within one of the Coma voids? In particular, how do they compare with the dwarf emission-line galaxies found in Bootes?

CHINCARINI: The four galaxies I mentioned have been found in the literature and the published data are as follows:

133624 + 2635	cz = 3994	Type = sp	m_j = 14.99	
125718 + 2808	3682	E	m_V = 16.81	(3.5 x 1.2 Kpc)
125706 + 2822	3651	SO	m_V = 17.20	
122648 + 2723	3819	--	m_V = 15.10	

DENG: It seems that too many filaments of clusters and super-clusters are along the line of sight in the diagrams you showed. It seems to be unreasonable. Do you think there are any effects existing in the observation which could cause this kind of distribution?

CHINCARINI: In the sample of Coma-A1367 I showed there are various groups, and the velocity dispersion of their members give the elongation, along the line of sight - I mentioned in the talk that in other cases distortions of the topology, at least in some regions, may be partly due to the large scale motion which various authors detected and similar to the one you referred to in the Hawaii meeting (see however R. Davies - this conference). However, I believe that the topological characteristics as found globally, probably sponge like, are by now demonstrated to be real.

TULLY: I can provide an update of the work on extremely large-scale structure that was mentioned. The original published work was based on an analysis of 214 rich clusters with redshifts less than 0.1 c, whereas 375 such clusters are now known. The concentration to the supergalactic plane is even stronger in the most recent sample. Of order 100 rich clusters participate in a structure that extends across 500 Mpc and has a FWHM thickness of 60 Mpc (H_o = 75).

https://doi.org/10.1017/S0074180900159236 Published online by Cambridge University Press