# OBSERVATIONS OF THE LARGE SCALE DISTRIBUTION OF GALAXIES

W. G. Tifft
Steward Observatory, University of Arizona, Tucson, Arizona
and
S. A. Gregory
Physics Dept., Bowling Green Univ., Bowling Green, Ohio

It has long been assumed that clusters of galaxies merge into a smooth "field" of isolated galaxies. Early estimates put 50% of all galaxies into the field. Using new redshift surveys over large areas we find the real distribution of galaxies to be very different. Nearly all galaxies are in clusters or groups covering a range of at least 1000 in mass and richness.

The first large scale survey was of a $6^{o}$ radius field centered on the Coma cluster (Tifft and Gregory 1976). This was extended by Gregory and Thompson (1978) to cover a 250 square degree region bridging the Coma and A1367 clusters. A1367 has properties similar to Coma (Tifft 1978). The extended survey shows that the two rich clusters lie in a supercluster containing at least four lesser groups and some scattered "isolated" galaxies. The foreground shows no galaxies which cannot be associated with groups. There are regions more than 20 Mpc in radius which are totally devoid of galaxies.

New observations of galaxies down to photographic magnitude 14.0 in a 500 square degree region surrounding the Perseus, A396, A347, A262, NGC507, and NGC383 clusters confirm the results of the Coma surveys. The groups form an enlongated supercluster (see figures) as originally suggested by Tifft, Hilsman, and Corrado (1975). The foreground is again very clumpy with one major void of radius close to 40 Mpc.

Galaxies in the Coma, Perseus, and Local superclusters which are not definite members of groups can be accounted for as 1) members of unidentified small groups, 2) remnants of loose clouds which may have been tidally disrupted, or 3) a small population which may have escaped from clusters. We conclude that all galaxies were probably formed in clusters. In a classical picture this implies that galaxies fragmented after clusters were formed. The observations are also consistent with galaxy formation by fragmentation and slow expansion of dense cores at the centers of clusters.

SAG acknowledges support from NSF grant AST 74-22597.



*M. S. Longair and J. Einasto (eds.), The Large Scale Structure of the Universe, 267-269.* 

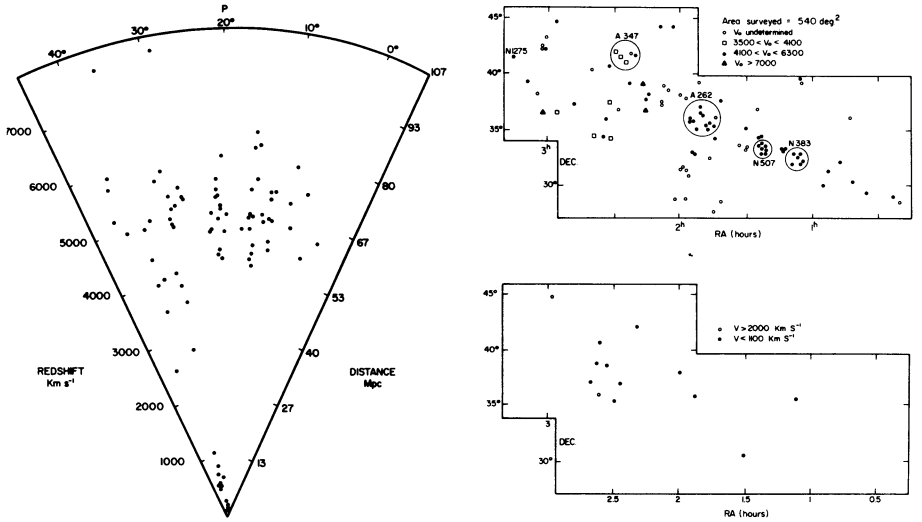


Figure 1. Redshift and spatial distributions (divided at $V_o$ = 3000) of galaxies in the Perseus supercluster. Wedge angle is taken along the line of clusters.

REFERENCES

Gregory, S. A. and Thompson, L. A. 1978, Ap.J. (in final preparation).
Tifft, W. G. 1978, Ap.J. (in press).
Tifft, W. G. and Gregory, S. A. 1976, Ap.J. 205, pp 696-708.
Tifft, W. G., Hilsman, K. A., and Corrado, L. C. 1975, Ap.J. 199, pp.16-18.

## DISCUSSION

*Chincarini:* I would like to emphasize that the gaps we observe in the velocity field give an upper limit to the number of possible "field" galaxies. A preliminary computation based on the velocity field in a magnitude-limited sample gives

$$\frac{dN(<m)}{d\Omega} < 1.0 \times 10^{-8} 10^{0.6m}$$

at about 2-3$\sigma$ level. Such a limit will be improved by more detailed computations.

*Ozernoy:* I am worried about your conclusion that the lack of bright galaxies in the field is evidence in favour of their origin in clusters. In fact, in the collapse of protoclusters, which is highly anisotropic, only part of the collapsing matter forms a gravitationally bound system. A significant part of the contracting protoclusters, after the formation of galaxies, may re-expand and become field galaxies.

https://doi.org/10.1017/S0074180900144651 Published online by Cambridge University Press

*Tifft:* The observed low limits on the galaxy density outside clusters or groups should provide important constraints on possible theories of the origin of clusters and galaxies. I also suggest that numerical N-body collapse studies consider formulating some indices to describe the number of isolated galaxies left over, and the shapes of structures formed, since these quantitites can be critically compared with the observations. The general statistical analysis of the surface distributions of galaxies is totally insensitive to small variations in isolated galaxy or small group populations. One of the most striking differences between the N-body collapse models with different $\Omega$ appears to be the number of "field" or isolated galaxies left over after the main collapse.

*Silk:* The apparently sharp boundaries and holes over large scales that are being inferred may partly be a function of the nature of the magnitude-limited sample. At the distance of the Coma Cluster, one is barely at the kneee in the galaxy luminosity function. Many fainter galaxies could be present, and it is possible that the more luminous galaxies are only found in dense regions.

*Tifft:* We have a partial test of this hypothesis by looking at groups and clusters as a function of distance. In the most nearby groups, we can investigate the distribution of galaxies to very much fainter absolute magnitudes than in more distant groups but there is not deterioration in the definition of these nearby groups. Therefore, we do not expect the distribution of faint galaxies to be very different from that of bright galaxies.

*Fall:* Do you have a numerical estimate of the density excess in the bridge connecting Coma and A 1367?

*Tifft:* It is premature to give any good estimate since the sample is incomplete. In particular the local Coma I cloud sits centrally in the field and makes it very difficult to estimate the number of slightly fainter galaxies belonging to the bridge population.

*Peebles:* If the groups and clusters tended to contract it would make them appear narrower in redshift distribution than would be expected under the assumption of pure Hubble expansion. Conceivably this is a partial explanation for the apparent sharp boundaries of the clouds of galaxies.

*Tifft:* Both the Coma and Perseus superclusters are quite extended spatially, a good fraction of a radian, but show a "constant" redshift along the entire length and very little dispersion. They therefore have negligible "depth" compared to width. They are "lines" or "sheets" perpendicular to the line of sight! It is true that radial collapse could offset part of the differential Hubble flow seen through the object but the collapse velocity could not easily match the Hubble flow at all points so I would still expect much more spread in "velocity depth" than is seen. I think that if we find many more cases of extended "thin" discs or linear structures all aligned perpendicular to the line of sight we will have a good case for an intrinsic redshift.

https://doi.org/10.1017/S0074180900144651 Published online by Cambridge University Press