Part IV

Superclusters and Intergalactic Dust

The Hydra-Centaurus Supercluster

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Abstract

We discuss the status of our work in the region $10^h < \alpha < 14^h$ and $-50° < \delta < -20°$. An estimated overdensity of about 2 for the visible mass could, coupled to the streaming motion detected by Lynden-Bell *et al.*, give $\Omega_0 \simeq 0.07$.

1 Introduction

The theoretical investigations by Fall (1975) and Peebles (1980 and references therein), among others, showed that an overdensity $\Delta\rho/\rho$ perturbs the Hubble flow by an amount $\Delta v/v$ given by the equation

$$\frac{\Delta v}{Hr} = \frac{1}{3}\frac{\Delta\rho}{\rho}\Omega_0^{0.6} \, . \tag{1}$$

There are at least two consequences:

i: On local scales, we expect a component of shear motion, if the distribution of the density perturbation is not isotropic and thus defines a preferential direction in space;
and

ii: we must define as the fundamental cell of the Universe, *i.e.* a region of space with the mean characteristics of the cosmos and therefore undistinguishable from any other region of equal volume, one which has no motion with respect to the microwave background and an internal energy density equal to the mean energy density of the Universe. Is the size of such a cell about 1/10 of the horizon or as large as the horizon itself? Furthermore, since a concept of inertial frame of reference in the above is included, shall we relax the above concept of cell and investigate the concept of random scale motion among otherwise identical parts of space?

From the observational point of view it is clear, indeed, that the strong local asymmetry in the distribution of mass due to the Virgo cluster slows down locally the general expansion. On the other hand, measurements of the microwave background show a dipole component in the direction $l = 269°$, $b = 28°$. Since the Virgo cluster is in the direction $l = 284°$, $b = 75°$, other density irregularities must perturb the Hubble flow in such a way that by combining the various motions on larger and larger scales we end up with a vector pointing in a direction which is in agreement with the observed dipole anisotropy of the microwave background.

The region of Hydra-Centaurus is becoming one of the most interesting targets of observational cosmology. Indeed, there is a long standing evidence that somewhere in this direction there is a large concentration of mass which perturbs the Hubble flow on a large scale.

Following the work by Rubin *et al.* (1976), it became clear that, unless we dismiss their results as due to some observational bias, we have to take into account the possibility of a perturbation in the general direction of Hydra-Centaurus. This point was stressed in a preliminary form by Chincarini (1982) who also noticed that the components of the motions were rather close to the supergalactic plane. The obvious reasoning was that the motion of the local group with respect to the microwave background had to be explained as the result of the various motion components generated by known local perturbations. Following a lecture series held in Rio de Janeiro, it was decided to begin a redshift survey in this region of the sky using the new facilities set up at the National Observatory of Brazil. More recently, observations were obtained at ESO/La Silla by Vettolani *et al.* and in South Africa by Fairall.

A detailed study on the search for motion with respect to the microwave background was published by Tammann and Sandage (1984, and it was clearly shown that all the data available indicated a density perturbation in the direction of Hydra-Centaurus. The most interesting results on this matter, however, came from the work of Burstein *et al.* (1986 and subsequent papers) who showed that there is a clear indication of motion of a large region of local space in the direction $l = 307°$, $b = 9°$. This region is located somewhat south of the Hydra-Centaurus supercluster toward Pavo-Indus.

In this paper we describe some of the results obtained so far in the region we are surveying.

2 Redshift surveys in the Hydra-Centaurus region

In the Hydra-Centaurus supercluster (*Fig. 1*), clusters of various richness are present; these are: the Antila cluster, the Centaurus cluster, the Hydra cluster and Klemola 27. A few areas have been surveyed for redshifts by Hopp and Materne (1985), Da Costa *et al.* (1986, 1987), Fairall *et al.* (1988). Clusters of galaxies in this region have been studied also by Melnick and Moles (1987) and by Lucey *et al.* (1986). As discussed below, important surveys in a region south of the one presented in *Fig. 1*, in Pavo-Indus, have been carried out by Fairall (1987) and more recently by Dressler (1988).

The analysis of the ESO-Uppsala catalogue (Lauberts 1982) using the percolation algorithm shows that between the Hydra and the Centaurus region the galaxian density is very low.

The redshift surveys demonstrate that the Hydra supercluster is connected to the

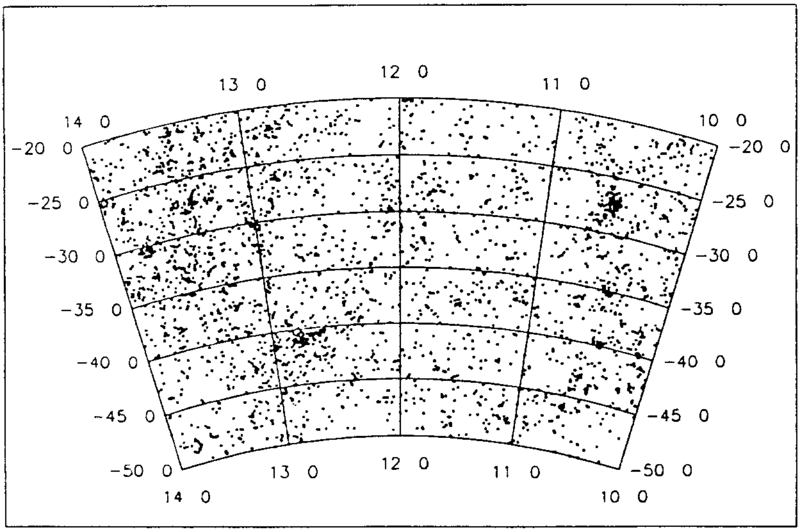

Fig. 1. Equal-area projection of the 3018 galaxies of the ESO-Uppsala catalogue in the survey region.

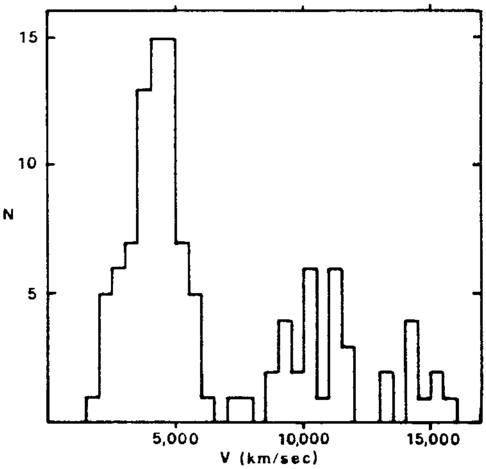

Fig. 2. The distribution in redshift in the region of Hydra-Centaurus observed by Da Costa *et al.* (1986).

Centaurus supercluster only through a low density filamentary [1] structure at about 3 000 km s^{-1}. The Hydra-Centaurus supercluster redshift distribution shows a peak at about 4 500 km s^{-1}. Other overdensities are detected at about 10 000 km s^{-1} and 15 000 km s^{-1} (*Fig. 2*) (Da Costa *et al.* 1987; Fairall *et al.* 1988). The redshift distri-

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[1] Here and in some previous work we use the word "filamentary" in a rather broad sense and not in the strict meaning of the word given in the Webster dictionary. In a similar way, we discuss the Hydra-Centaurus supercluster as the complex with redshifts in the range 2 500 – 5 000 km s^{-1}, leaving to more detailed discussions the subgrouping in redshift space.

bution continues with similar characteristics in the Pavo-Indus region, again showing a peak at about 4 600 km s^{-1} (Fairall 1987) (*Fig. 3*).

Fairall *et al.* (1988) compiled a redshift catalogue of 484 objects with magnitudes brighter than $B_T = 14^{\mathrm{m}}.5$. At the distance of the Hydra-Centaurus supercluster we are, therefore, sampling the luminosity function at a somewhat fainter magnitude than the break. In sample A, in which 251 galaxies have magnitudes measured on the ESO plates by Lauberts, redshifts are known for 354 galaxies and the survey is 73 % complete. In sample B the redshift is now known for 596 galaxies so that the survey is 50 % complete. The redshift completeness map is given in *Fig. 4*.

The distribution of galaxies with redshift 2 500 km s^{-1} < v < 4 500 km s^{-1} (*Fig. 5*) shows a low density connection between the regions of Hydra and Centaurus. Most

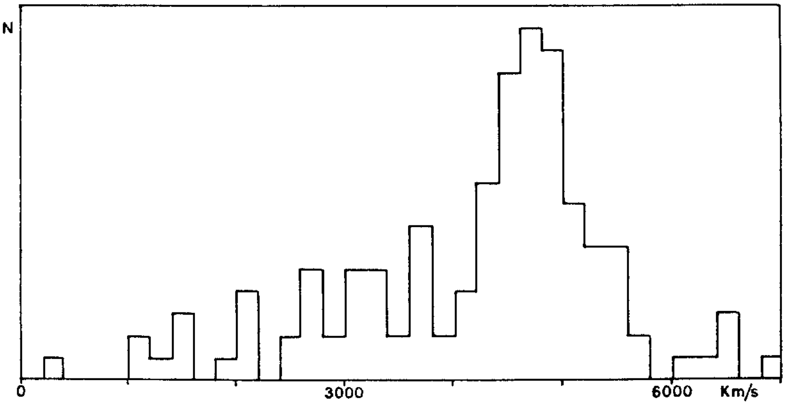

Fig. 3. The distribution in redshift in the region of Pavo-Indus observed by Fairall (1987).

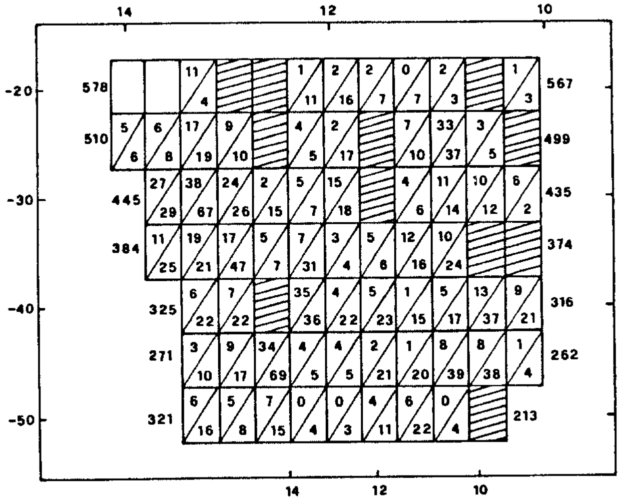

Fig. 4. Redshift completeness map for sample A (see text).

of the galaxies linking the two regions are at redshifts of about 3 000 $\mathrm{km\,s^{-1}}$ and at a declination of about $-37°$. On the other hand, in the redshift range $4\,500\ \mathrm{km\,s^{-1}} < v < 6\,500\ \mathrm{km\,s^{-1}}$ (*Fig. 6*), we do not detect galaxies in the region $11^{\mathrm{h}} < \alpha < 12^{\mathrm{h}}30^{\mathrm{m}}$ and $-40° < \delta < -20°$. Inspection of the redshift completeness map (*Fig. 4*) shows that the northern part of the void is poorly sampled and we cannot exclude the existence of a northern boundary at about $\delta = -20°$.

The agglomerate of galaxies in Centaurus is formed by various subgroupings. Two concentrations of galaxies are centered at about 3 050 $\mathrm{km\,s^{-1}}$ and 4 500 $\mathrm{km\,s^{-1}}$ (see also Lucey *et al.* 1986) and the concentration at 3 050 $\mathrm{km\,s^{-1}}$ seems to be formed by two subgroups separated by about 7°.

A small and rather well bounded void is visible in the cone diagram of *Fig. 7.* The cone diagram, α *vs.* redshift, covers the declination range $-50° < \delta < -20°$ so that the projected void is about 30° long in declination and about $6\overset{\circ}{.}1$ in right ascension at a redshift of about 4 200 $\mathrm{km\,s^{-1}}$. We will call this a pipe-shaped void.

The survey by Dressler (1988), bounded by the galactic coordinates $-35° < b < +45°$ and $290° < l < 350°$, shows a similar distribution in redshift space (his *Fig. 2*) with the difference that the peaks at 10 000 $\mathrm{km\,s^{-1}}$ and 15 000 $\mathrm{km\,s^{-1}}$ are less prominent when compared to the 4 500 $\mathrm{km\,s^{-1}}$ peak.

It is quite evident from the above redshift surveys that a density enhancement over a very large region is present in the redshift range 3 000 – 5 000 $\mathrm{km\,s^{-1}}$ with a peak at about 4 500 $\mathrm{km\,s^{-1}}$. Substructure is indicated.

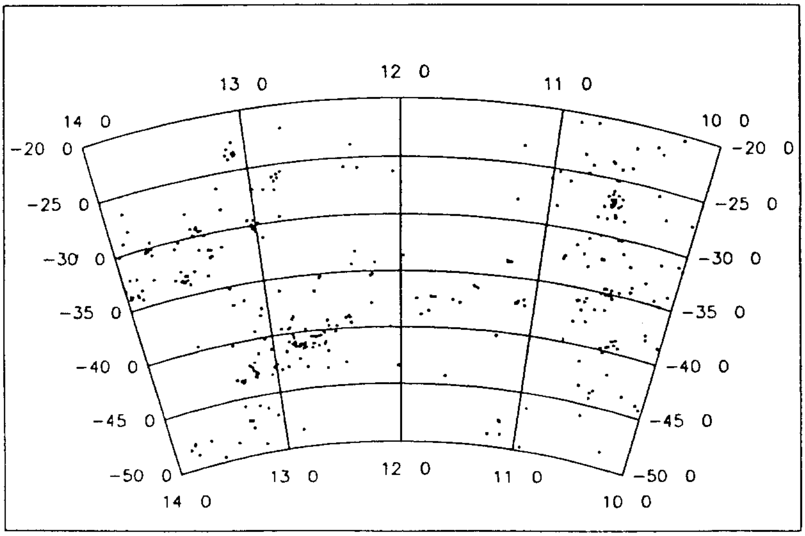

Fig. 5. Distribution of galaxies from sample B with radial velocities between 2 500 $\mathrm{km\,s^{-1}}$ and 4 500 $\mathrm{km\,s^{-1}}$ in equal-area projection.

3 A possible value for Ω_0?

Lynden-Bell *et al.* (1987), using a sample of 385 elliptical galaxies, show that the motions are best described by a flow toward a mass concentration centered on $l = 307°$, $b = 9°$ at a redshift of about $(4\,350 \pm 350)\,\mathrm{km\,s^{-1}}$. The streaming motion at

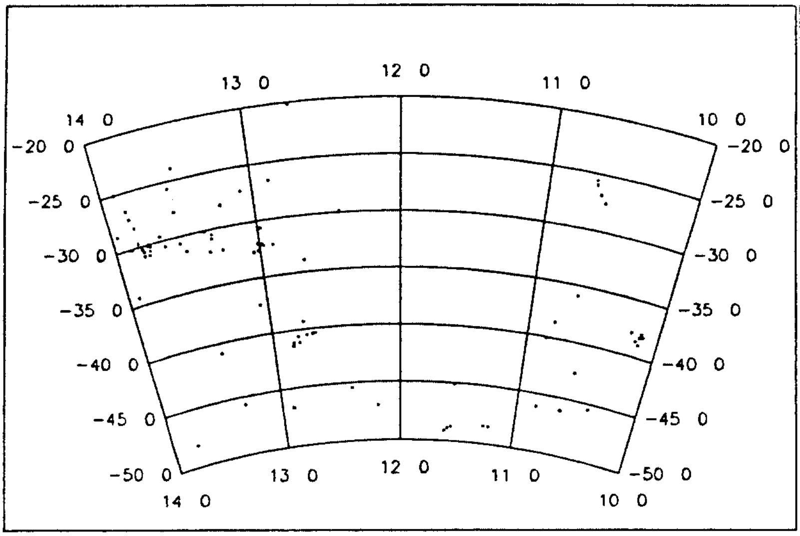

Fig. 6. Distribution of galaxies from sample B with radial velocities between 4 500 km s^{-1} and 6 500 km s^{-1} in equal-area projection.

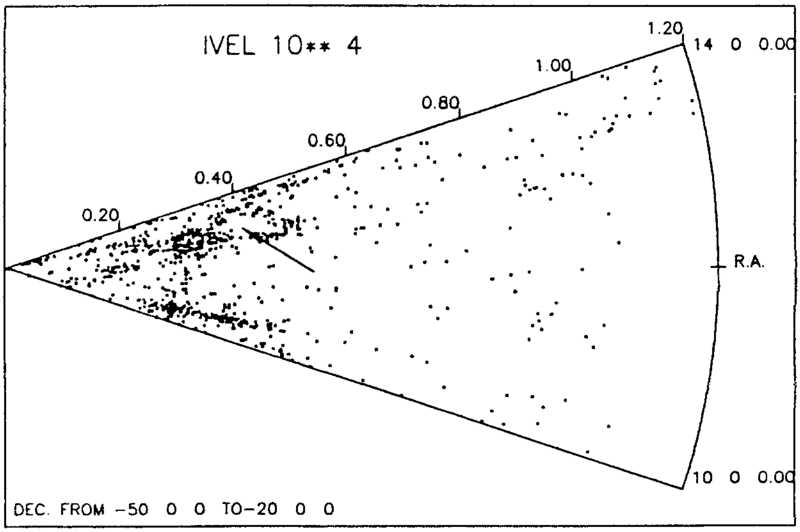

Fig. 7. Wedge diagram, compressed in declination, for the whole area. The arrow points to a pipe-shaped void.

the Sun is $(570 \pm 60)\,\mathrm{km\,s^{-1}}$.

The redshift histograms can also be used as a measure of overdensity with respect to the mean density of the Universe. Indeed, a measure of the density perturbation is given by the relation:

$$\frac{\Delta\rho}{\rho} = \frac{\int_{z_1}^{z_2} \mathrm{N_{obs}(z)\,dz}}{\int_{z_1}^{z_2} \langle \mathrm{N} \rangle_{\mathrm{expected}}(\mathrm{z})\,\mathrm{dz}} - 1\,, \tag{2}$$

where $\langle \mathrm{N} \rangle_{\mathrm{expected}}$ is the number of objects we would observe in the solid angle defined by the sample, assuming uniform distribution of galaxies and counts limited at the same limiting magnitude as the sample and smoothed all over the sky. These counts define the mean density of the Universe and are known (they must be corrected for the Virgo cluster, see also Olowin *et al.* 1988).

Our sample (Fairall *et al.* 1988) covers a solid angle of 0.43 sterad and gives an excess density

$$\frac{\Delta\rho}{\rho} = 2.37\,. \tag{3}$$

The sample by Dressler (1988) extends over an area of 0.85 sterad (since the redshifts have not been published an estimate has been made using his *Fig. 2*) and gives

$$\frac{\Delta\rho}{\rho} = 1.2\,. \tag{4}$$

Assuming a shear motion model (Eqn. 1) and a mean overdensity of 1.8, we obtain

$$\Omega_0 = 0.07\,. \tag{5}$$

Are we really overestimating the density fluctuations by about a factor 10 using visible matter?

On the other hand, the effect of the Perseus-Pisces supercluster (see Da Costa *et al.* 1986) and/or the presence of a weaker perturbation (located further away) could favor a larger value of Ω_0.

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