LARGE-SCALE STRUCTURES UNCOVERED BEHIND THE SOUTHERN MILKY WAY

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Abstract

In our ongoing deep search for galaxies behind the southern Milky Way by systematic visual inspection of the IIIaJ ESO/SRC-survey to a diameter limit of D$\geq$ 0.'2, we have now charted over 10000 new galaxies within $265° \lesssim \ell \lesssim 340°$, $|b| \lesssim 10°$. Our most recent extension covers a substantial region around the predicted position $(\ell, b, v) = (320°, 0°, 4500$ km/s) of the Great Attractor (GA) [4].
In this report we concentrate on the detection of an extreme overdensity centered on the cluster A3627. This overdensity turns out to be a rich cluster with a large fraction of early type galaxies. Our redshift observations put it close to the GA in velocity-space $(\ell, b, v_{obs}) = (325°, -7°, 4887$ km/s). Moreover, the first mass estimates prove A3627 to be a very massive cluster, $\mathcal{M} \sim 7 \cdot 10^{15} \mathcal{M}_{\odot}$. The mass of the cluster itself cannot fully explain the observed infall motions into the GA ($5 \cdot 10^{16} \mathcal{M}_{\odot}$ [11]), but A3627 seems to be the central peak of a much larger structure/supercluster, which corresponds well with the general predictions of this mass excess.

1 Introduction

The Milky Way obscures about 25% of the optical extragalactic sky. This is a severe restriction in the study of various extragalactic topics:
(a) The connectivity of structures across the Milky Way. Most of the known superclusters disappear in the ZOA. What is their true extent?
(b) The observed infall into the Great Attractor at $(\ell, b, v_{obs}) \sim (320°, 0°, 4500$ km/s) [11, 4]. Is this predicted mass overdensity in the form of galaxies?
(c) The origin of the peculiar motion of the Local Group with respect to Cosmic Microwave Background Radiation (CMB). Can the dipole in the CMB be explained by the gravity of the irregular mass/galaxy distribution in the *whole* sky?
(d) The internal dynamics of the Local Group.
Next to the distribution of clusters, sheets and voids, individual *nearby* galaxies are also relevant as their gravitational perturbation would be significant purely because of their proximity [5].

In order to uncover the galaxy distribution in the 20° wide strip known as the 'Zone of Avoidance', we have embarked on a deep search for partially obscured galaxies down to faint magnitudes and small sizes, i.e. a diameter limit of D= 0.'2. We have started our survey in the southern hemisphere, because of the questions related to the dipole in the CMB and the infall into the GA which both point close to the southern Galactic Plane (marked in Fig. 1).

2 The newly discovered galaxies in the southern ZOA

To date, 50 fields of the ESO/SRC-survey have been visually inspected. The surveyed area lies within $265° \lesssim \ell \lesssim 340°, |b| \lesssim 10°$. Its borders are outlined in Fig. 1. Within the surveyed area of $\sim$ 1200 sq. deg., 10276 new galaxies with D$\geq$ 0.'2 have been identified next to the 269 Lauberts-galaxies [10] with D$\geq$ 1$'$ in this area. Their distribution is displayed in an Aitoff projection of the southern sky together with all Lauberts galaxies. In the mean, the galaxy

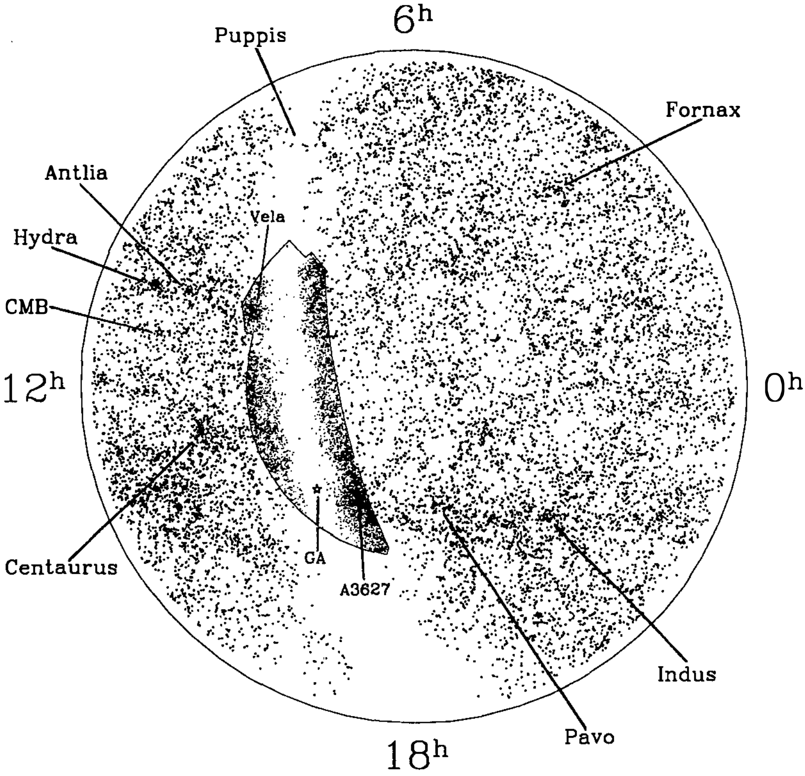

Figure 1: An equal-area projection of the galaxy distribution in the southern hemisphere displaying all Lauberts-galaxies (D$\geq$ 1$'$), complemented with the 10276 galaxies detected in our deep galaxy search behind the southern Milky Way (D$\geq$ 0.'2). The about 1200 sq. deg. surveyed systematically to date is outlined. The most prominent features are labelled.

density is well correlated with the foreground extinction A_B as traced by the HI-column-density to densities as low as 0.5 gal/sq. deg. For $A_B \gtrsim$5-6mag, respectively N(HI)$\gtrsim 4-6\cdot 10^{21}$ cm^{-2}, the ZOA remains opaque [5, 7].

Above this band, distinct filaments and round concentrations can be recognized. They must have their origin in extragalactic large-scale structures. Some of these features seem to align with the known galaxy distribution, as *e.g.*, a filament above the Galactic Plane (GP) which points toward the Centaurus cluster, and the filament from the Hydra and Antlia clusters across the dipole direction in the CMB towards the prominent overdensity in Vela. However, the 2-dimensional galaxy distribution alone can be misleading. Redshift measurements are required to map the galaxies in 3 dimensions. For instance, our follow-up redshift observations trace a filament/supercluster from Hydra across the ZOA to $b = -10°$ at a mean velocity of 2500-3000 km/s, but the prominent overdensity in Vela is not part of it. The latter is part of a more distant (6000 km/s) shallow overdensity.

Details on the search procedure and earlier results can be found in [6, 7, 8, 9].

The cluster A3627: The most extreme overdensity is found within our recent search extension. It is centered on the cluster A3627 at $(\ell, b) = (325°, -7°)$ and is at least a factor 10 denser compared to regions at similar extinctions and a factor of 3 denser than the Vela-overdensity mentioned above. Although it is (a) the only Abell cluster identified behind the plane of the Milky Way, (b) classified as a rich, nearby cluster by [1], and (c) within a few degrees of the predicted center of the GA [4], this cluster has not received any attention. Part of the reason is the diminishing effects of the foreground obscuration. This cluster is hardly discernable in, for instance, the distribution of Lauberts galaxies (cf. left panel of Fig. 2). However, the diameters

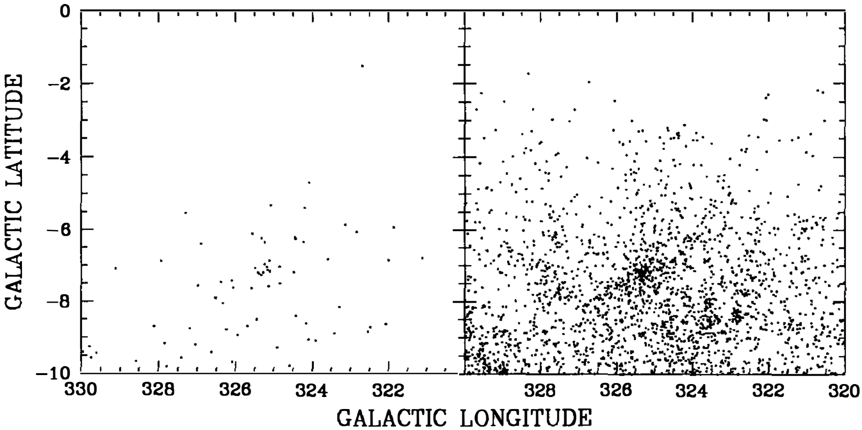

Figure 2: 10° × 10° fields centered on the cluster A3627. The left panel shows the Lauberts galaxies (D≥ 1'.0), the right panel the galaxies identified in our survey (D≥ 0'.2).

of the galaxies in this overdensity peak are just *below* the diameter limit of Lauberts. With slightly lower absorption its presence could have been as prominent as in our survey. This is illustrated in a close-up of the cluster area in Fig. 2. The left panel shows the previously known Lauberts-galaxies and the right panel the galaxies identified by us. In addition, the magnitudes and diameters are significantly brighter and larger than the mean of our survey ($B_J = 16^{m}.7$, D= 0'.7 compared to $B_J = 18^{m}.0$, D=0'.4), or the mean at similar latitudes.

The new data support the classification of A3627 as a rich cluster. The core radius of the cluster is $R_c = 10\farcm4$ with a central density of $N_o = 800$ gal/sq.deg. This translates to $R_c = 0.3$ Mpc for an approximate distance of D= $v_0/H_0 = 93$ Mpc (with $v_0 = 4660$ km/s as determined below and an adopted Hubble constant $H_0 = 50$ km/s/Mpc). Like all rich clusters, A3627 contains a large fraction of early type galaxies (50% in the core of this cluster, 25% within its Abell radius). This probably explains why this cluster is *not evident* at all in the distribution of IRAS-galaxies and IRAS-galaxy candidates which is very smooth in this area.

3 Results based from redshift observations

To assess the implications of the uncovered extragalactic large-scale features for the dynamics of the nearby Universe we are determining their redshifts. This is being pursued with three complementary observational approaches: (a) multifiber spectroscopy with OPTOPUS and MEFOS at the 3.6m telescope of ESO in the densest regions, (b) individual spectroscopy of the brightest galaxies with the 1.9m telescope of the SAAO, and (c) 21cm observations of the extended but low surface-brightness spirals with the 64m Parkes radio telescope (cf. [8, 9]). So far we have obtained 1079 new redshifts in our search area. They allow us to trace large-scale structures out to recession velocities of $v \gtrsim 25000$ km/s.

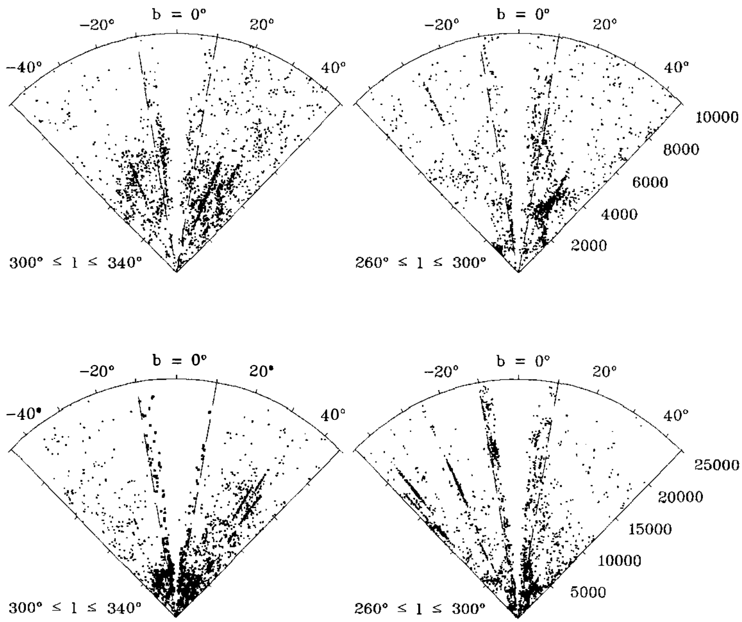

Figure 3: Redshift cones of galaxies in the GA-region ($300° \le \ell \le 340°$, left panels) and the Hydra/Antlia region ($260° \le \ell \le 300°$, right panels) for velocities $v_0 \le 10000$ km/s (top) and $v_0 \le 25000$ km/s (bottom). Within the displayed latitude range ($-45° < b < 45°$), the area investigated here ($|b| \lesssim 10°$) is delineated by dashed lines.

The galaxy distribution in redshift space is shown in Fig. 3 with redshift slices out to 10000 km/s (top) and 25000 km/s (bottom), for the Hydra/Antlia region (right panels) and the GA region (left panels). Our new data ($|b| \lesssim 10°$) is shown together with the data from the *Southern Redshift Catalogue* [3], a compilation of all measured redshifts in the southern hemisphere for the latitude range of $-45° < b < 45°$.

The main earlier results (cf. [6, 8, 9]) are a confirmation of the suspected Hydra/Antlia extension from Hydra $(\ell, b, v) = (270°, 27°, 2800$ km/s) to Antlia (273°, 19°, 2500 km/s) across the GP to about $b = -15°$ where it seems to end at the border of a void (top right panel), and the mapping of a previously unrecognized shallow but significant overdensity in Vela (280°, 6°, 6000 km/s). Note furthermore the seemingly preferred redshift-range of $\sim$ 16-18000 km/s in the lower panels. Is this a chance alignment of clusters, or an indication that the Shapley clusters above the GP are part of a super-structure that crosses the GP and connects to the Horologium clusters 100° further away - hence a coherent structure of about 600 Mpc?

The cluster A3627: Although we have so far covered only part of the cluster A3627 with our redshift measurements, the data already reveal it to be one of the most striking clusters in the nearby slices. The 'finger of God' is quite pronounced $(325°, -7°, 4887$ km/s) and does not exhibit the bimodal velocity distribution of the Centaurus cluster (302°, 22°, 3000&4500km/s). In fact, the velocity distribution of the 96 galaxies observed by us within the Abell radius of A3627, as displayed in Fig. 4, demonstrates it to be gaussian. The mean velocity and dispersion of the cluster are $< v_{obs} >= 4887$ km/s ($v_0 = 4660$ km/s) and $\sigma = 864$ km/s.

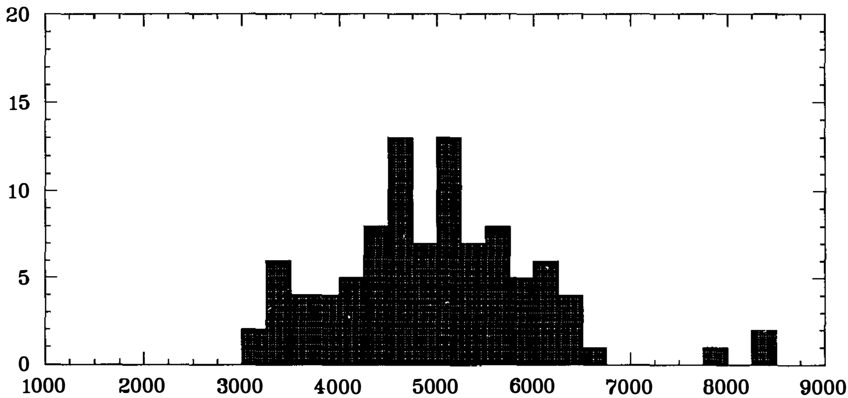

Figure 4: The velocity distribution of the 96 galaxies with measured redshifts within the Abell radius of A3627. The mean velocity and dispersion of the cluster, are $< v_{obs} >= 4887$ km/s, $\sigma = 864$ km/s, not including the 3 galaxies at $\sim$ 8000 km/s.

The large dispersion of A3627 indicates it to be quite massive. Using the formalism given by Rood et al. [12], a preliminary estimate finds (H_0=50 km/s/Mpc)

$$\mathcal{M}_{A3627} = 9 \cdot R_{eff} \cdot \sigma^2/G = 7 \cdot 10^{15} \mathcal{M}\odot,$$

where the effective radius is $R_{eff} = 155'$. This cluster is hence an order of magnitude more massive than the Centaurus cluster. Its overall properties are similar to the well-studied nearby rich clusters Perseus and Coma, and although it has not been detected previously in X-ray, ROSAT-observations (0.1-2.4 keV) prove it to be among the brightest 10 galaxy clusters [2].

A3627 versus GA: Is the cluster A3627 responsible for the observed infall into this area?

The predicted mass of the GA is of the order of $5 \cdot 10^{16} \mathcal{M}\odot$ [11]. This is an order higher than the mass derived for A3627. However, the core-radius of the predicted overdensity is large ($\sim$20 Mpc). The mass distribution as mapped by POTENT from peculiar velocity fields describes structures only on supercluster scales because of the large smoothing windows (1200 km/s). But these potential wells generally have a rich cluster at their center, which is consistent with our findings. A3627 is embedded in a larger structure. The mean velocity of the cluster does not change within the immediate surroundings of the cluster. Moreover, the nearby slices (Fig. 3, top panels) are suggestive of a very large-scale coherent structure, starting at Pavo $(332°, -24°)$ moving towards the density peak of A3627 at slightly larger velocities (left panel). This supercluster then seems to continue to the Vela-overdensity at 6000 km/s. First traces are seen in the left panel above the opaque part of the Milky Way, but it is very apparent in the right panel. A second branch might bend back from A3627 towards the Centaurus and/or Hydra & Antlia clusters (see also Fig. 1).

Although the mass of the here recognized massive cluster A3627 alone does not suffice to fully explain the observed velocity field in this area, the total mass of this supercluster centered on this rich cluster most likely will. A more quantitative analysis will be made with the forthcoming data as soon as we have finished our observations in this region.

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