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THE SUPERGALACTIC PLANE REDSHIFT SURVEY: A CANDIDATE FOR THE GREAT ATTRACTOR

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ABSTRACT

Redshift measurements, nearly 600 of which are new, are compiled for ~900 galaxies in a survey toward the apex of the large-scale streaming flow for ellipticals. The velocity histogram shows that the excess in galaxy number counts in this area is due to a substantial concentration of galaxies with discrete peaks at $V \sim 3000$ km s^{-1} and $V \sim 4500$ km s^{-1}. The centroid of the distribution, nicknamed the "great attractor," is found to be at $V \sim 4000$ km s^{-1}, in good agreement with a model by Lynden-Bell *et al.* of a gravitational origin for the peculiar velocity field of elliptical galaxies. The amplitude of the overdensity can also be compared to that predicted by the dynamical model, although such a comparison is preliminary because the average density of the local universe on the appropriate scale is uncertain due to incomplete sampling. With the available calibration, the amplitude of the great attractor agrees well with the model. Low values of the cosmological density parameter $\Omega \sim 0.1$–0.2 are derived (assuming light traces mass), but the ability of simple spherical models to give reliable estimates of Ω is questioned.

Subject heading: galaxies: redshifts

I. INTRODUCTION

Aaronson *et al.* (1982) have shown that the local Hubble expansion field of galaxies is being decelerated by the Local Supercluster. From this one expects a peculiar velocity of the Local Group of ~250 km s^{-1} toward Galactic coordinates $l = 284°$, $b = 74°$ but, in fact, measurements of the microwave dipole anisotropy (e.g., Fixsen, Cheng, and Wilkinson 1983) indicate a much higher velocity in a substantially different direction. Shaya (1984), Sandage and Tammann (1984), and Aaronson *et al.* (1986), among others, have suggested that the so-called Hydra-Centaurus (H-C) supercluster, an observed concentration of glaxies at a velocity distance of ~2500–4000 km s^{-1} (Chincarini and Rood 1979), is responsible for the additional deceleration of the Local Group from its unperturbed Hubble expansion velocity. However, this model is contradicted by recent measurements of peculiar velocities of ~1000 km s^{-1} (away from the Local Group) for ellipticals (Dressler *et al.* 1987) and spirals (Aaronson *et al.* 1987) in the H-C supercluster. These peculiar velocities indicate that the mass responsible for the deceleration is more remote.

A dynamical model by Lynden-Bell *et al.* (1987) of the peculiar velocity field for elliptical galaxies points to a massive overdensity beyond the H-C supercluster. Dressler *et al.* originally described the flow pattern as a dipole field with an amplitude of approximately 600 km s^{-1} toward $l = 312°$ and $b = 6°$, a direction near the intersection of the Galactic and supergalactic planes. However, Lynden-Bell *et al.* show that the data better match the velocity field generated by a $\sim 5 \times 10^{16}$ solar mass enhancement at a velocity distance of ~4400 km s^{-1} in the direction $l = 307°$, $b = 9°$. The model inflow velocity at the distance of the Local Group is found to be 570 ± 60 km s^{-1}, considerably larger than the "inflow" of ~250 km s^{-1} induced by the Local Supercluster.

In this new picture, the mass center of the supergalactic plane is located in this more distant concentration, with the original H-C supercluster now a foreground object with a high "infall" velocity toward it. (In fact, there are few available data for ellipticals in the Hydra and Antlia clusters and they show a *lower* peculiar velocity. Hydra and Antlia are close to one another in direction but collectively are 25° away from the Centaurus cluster [see Fig. 7 of Lynden-Bell *et al.*] which lies *in* the supergalactic plane. Therefore, to be more precise in the following discussion, the foreground concentration will be called the *Centaurus* supercluster.) If this model is correct, galaxies in the more distant, more massive enhancement should show significantly smaller peculiar velocities than Centaurus. Verification of this requires yet unavailable distance determinations (independent of those implied by the Hubble velocity) obtainable with the Tully-Fisher method for spirals or the $D_n - \sigma$ relation for ellipticals and bulges of disk galaxies, for example.

The paper is organized as follows. Section II describes a redshift survey designed to test the Lynden-Bell *et al.* model that there is a previously unidentified overdensity of galaxies in the direction of the flow pattern for elliptical galaxies. Section III presents results of the survey, now 64% complete, and shows how the direction, distance, and amplitude of the detected overdensity compare with predictions of the model. Section IV contains a further discussion of this result and implications for future research.

II. A REDSHIFT SURVEY CENTERED ON THE SUPERGALACTIC PLANE

In a galaxy map of the sky produced by Ofer Lahav (see Lynden-Bell *et al.* Fig. 8) a substantial increase in the number counts of galaxies is seen in the approximate direction specified by the Lynden-Bell *et al.* model. Although it appears to be the dominant feature in the galaxy distribution (within a velocity distance of approximately 6000 km s^{-1}) in one hemisphere of the sky, this concentration in the supergalactic plane has apparently not been recognized as a discrete structure. The primary aim of the present research is to provide a redshift distribution for galaxies in this region to test if this enhancement in luminosity represents a true density enhancement. Preliminary evidence that this is the case has been presented in the form of redshift histograms for selected regions by Lynden-Bell *et al.* (1987) in the approximate direction of the elliptical galaxy flow. These data show a concentration of galaxies at ~4000–5000 km s^{-1}, beyond the ~3000 km s^{-1} distance of the H-C supercluster.

To explore more fully and systematically the angular extent and density of this more distant mass concentration I began a redshift survey for galaxies in area of approximately 1 sr toward the apex of the elliptical galaxy flow, bounded by Galactic coordinates $-35° < b < +45°$, $290° < l < 350°$. The survey, centered on the intersection of the Galactic and supergalactic planes, is referred to as the Supergalactic Plane Survey (SPS). The region has been little studied because both the CfA Redshift Survey (Huchra *et al.* 1983) and Southern Sky Redshift Survey (herafter SSRS, da Costa *et al.* 1987) are limited to Galactic latitudes above 30°.

The SPS consists of 1403 galaxies with diameters $D \gtrsim 1'.2$ selected from the ESO galaxy catalog (Lauberts 1982) according to the criterion of the SSRS:

$$\log(D1) - 0.235AT \log(D1/D2) \geq 0.10 , \quad (1)$$

where $D1$ and $D2$ are the major and minor axis diameters, in arcminutes, and $AT = 0.950$ for galaxies typed E–SO and $AT = 0.895$ otherwise. The mean velocity of galaxies selected this way is ~5000 km s^{-1}, well-suited for the task at hand. The galaxies in the sampled region are plotted in Figure 1. The obscuration of the Galactic plane is a conspicuous feature of the galaxy distribution, nevertheless, many galaxies are still seen at Galactic latitudes as low as 5°. The total solid angle covered is 1.21 sr, but a value of 0.85 sr has been adopted after subtracting the area $-10° < b < +10°$ as representative of that lost due to Galactic extinction.

In January and April of 1987 I obtained spectra for ~580 galaxies in the survey with du Pont Telescope at Las Campanas Observatory. Radial velocities accurate to ~50 km s^{-1} have been determined from these spectra. A catalog of the individual velocities, including notes on the data taking and reduction techniques, will be published upon completion of the survey.

When combined with ~300 velocities already listed in the ESO catalog or obtained by Menzies, Coulson, and Sargent (1987), this brings the number of measured redshifts to 896. In comparison, the SSRS now includes 1657 measured redshifts out of 1963 targets. This incompleteness factor of ~15% is mainly due to galaxies of very low surface brightness that are included in a diameter-limited sample but would have been excluded in a magnitude-limited sample. In order to provide a fair comparison with the more complete SSRS, galaxies in the present sample were selected to provide a complete subset. Redshifts are available for 618 of the 702 galaxies in the list ending in the numbers 1, 2, 4, 6, 8. This subset samples the entire region fairly and has no bias with respect to apparent diameter, the criterion for inclusion in the catalog. The com-

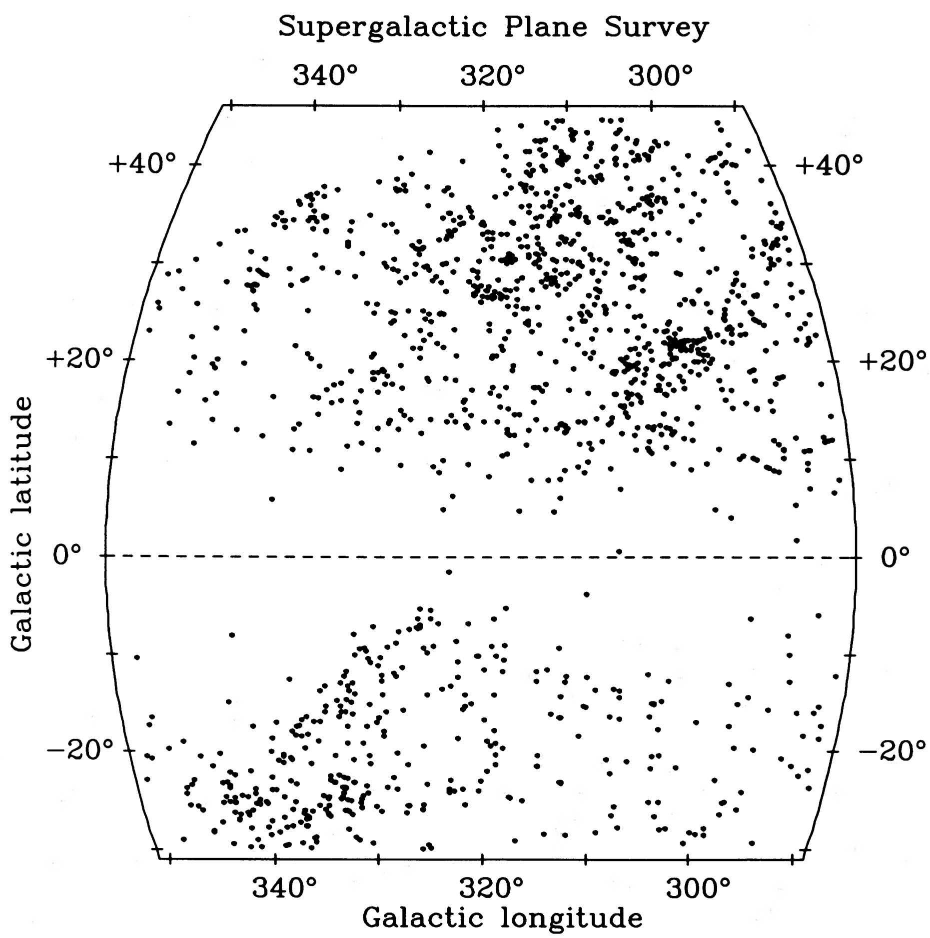

FIG. 1.—Area covered in the Supergalactic Plane Survey. Each point represents a galaxy selected by the criteria of the SSRS.

pleteness fraction of 88% for this subset is comparable to the SSRS completeness fraction and thus allows for direct comparison of the two samples. This comparison shows that the only difference between the "complete" sample of 618 and the entire sample of 896 is that galaxies with $V < 2000$ km s^{-1} are underrepresented by $\sim$30%. The missing 18 ± 4 galaxies are of little importance to the following discussion, so the entire sample will be adopted as representative of the completed SPS and SSRS.

III. RESULTS AND DISCUSSION

a) *A Concentration of Galaxies at $V \sim 4000$* km s^{-1}

The principal result of this paper is shown in Figure 2, a histogram of observed heliocentric velocities for the 896 galaxies. It is clear that most of the luminosity enhancement of the Lahav map is part of a coherent structure at 2000 km s^{-1} $< V <$ 5500 km s^{-1}. This is a likely candidate for the source of the misssing component of the Local Group motion relative to the microwave background radiation (MWB) and the cause of the peculiar velocity field described by Lynden-Bell *et al.*

The structure shows two distinct peaks: the Centaurus supercluster at $V \sim 3000$ km s^{-1} and a more distant concentration at $V \sim 4500$ km s^{-1}. These two peaks are better explored by plotting "pie-diagrams" and velocity histograms for four intervals of galactic latitude. Figures 3*a* and 4*a* show the region $-30° < b < -15°$ containing the Pavo-Indus supercluster. The dominant concentration of galaxies is at $V = 4500$ km s^{-1}. Figure 3*a* also reveals a substantial void at $l \sim 300°$ and $V < 3000$ km s^{-1} and possibly another at $V \sim 4000$ km s^{-1}. Figures 3*b* and 4*b* show the region crossing the galactic plane. The obvious concentration at $V \sim 5000$ km s^{-1} suggests that much of the higher velocity peak of Figure 2 is hidden by the Galactic plane. Figures 3*c* and 4*c* show the region $+15° < b < +30°$ which includes the Centaurus supercluster. Much of the low-velocity peak of Figure 2 comes from a small region surrounding the Centaurus cluster, clearly visible in Figure 3*c*. A small enhancement behind seems to connect the Centaurus supercluster to the more distant concentration seen for $b < +15°$. Figure 3*d* shows a more filamentary structure for $+30° < b < 45°$, which again contains enhancements at 3000 km s^{-1} and 4500 km s^{-1} (Fig. 4*d*).

The two peaks in Figure 2 are of comparable amplitude but it does not follow that the total number of galaxies are also comparable. The selection criterion of the survey biases against more distant galaxies ($V > 1000$ km s^{-1}). An empirical method of estimating the bias is to compare the SPS to the SSRS, a survey over a larger volume selected from the same catalog by the same criterion. The SSRS survey (renormalized to the area of sky covered by the SPS survey) is shown as the dashed histogram in Figure 2. Because the SSRS samples a volume twice as large as that of the SPS, it should better average over large inhomogeneities (like the Local Supercluster or voids) and provide at least a rough estimate of the way such a survey would sample a universe of *uniform* density. This can then be used to estimate the relative number of galaxies actually present in the two peaks, also needed to find the centroid of the galaxy distribution.

In reality, the reliability of the SSRS as a calibrating sample is unproven. As pointed out by M. Geller, the referee of this paper, observed galaxy fluctuations are of a sufficiently large amplitude and scale that even a relatively large volume survey like the SSRS could contain significant fluctuations on scales of several thousands of kilometers per second (see, e.g., deLapparent, Geller, and Huchra 1986). In fact, the SSRS shows no

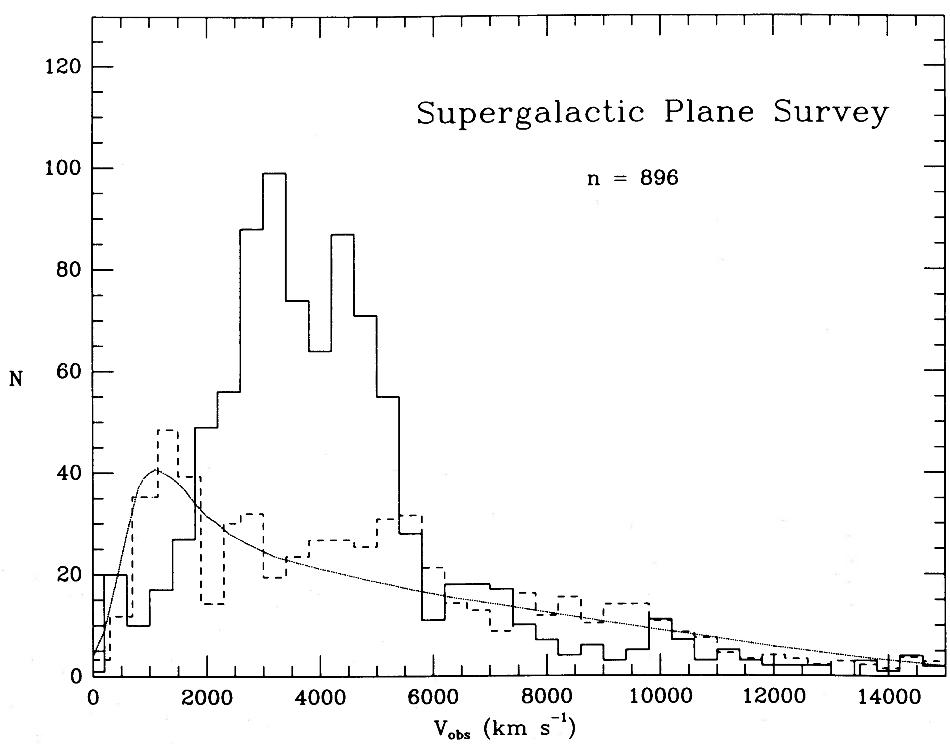

FIG. 2.—Velocity histograms for 896 SPS galaxies and for the 1657 SSRS galaxies (raw data ⇒ dashed line, smoothed data ⇒ dotted line) renormalized to the SPS area of 0.85 sr. Assuming that the SSRS represents a representative sampling of the universe, a large overdensity is seen in the SPS for $2000 < V < 5500$ km s^{-1}.

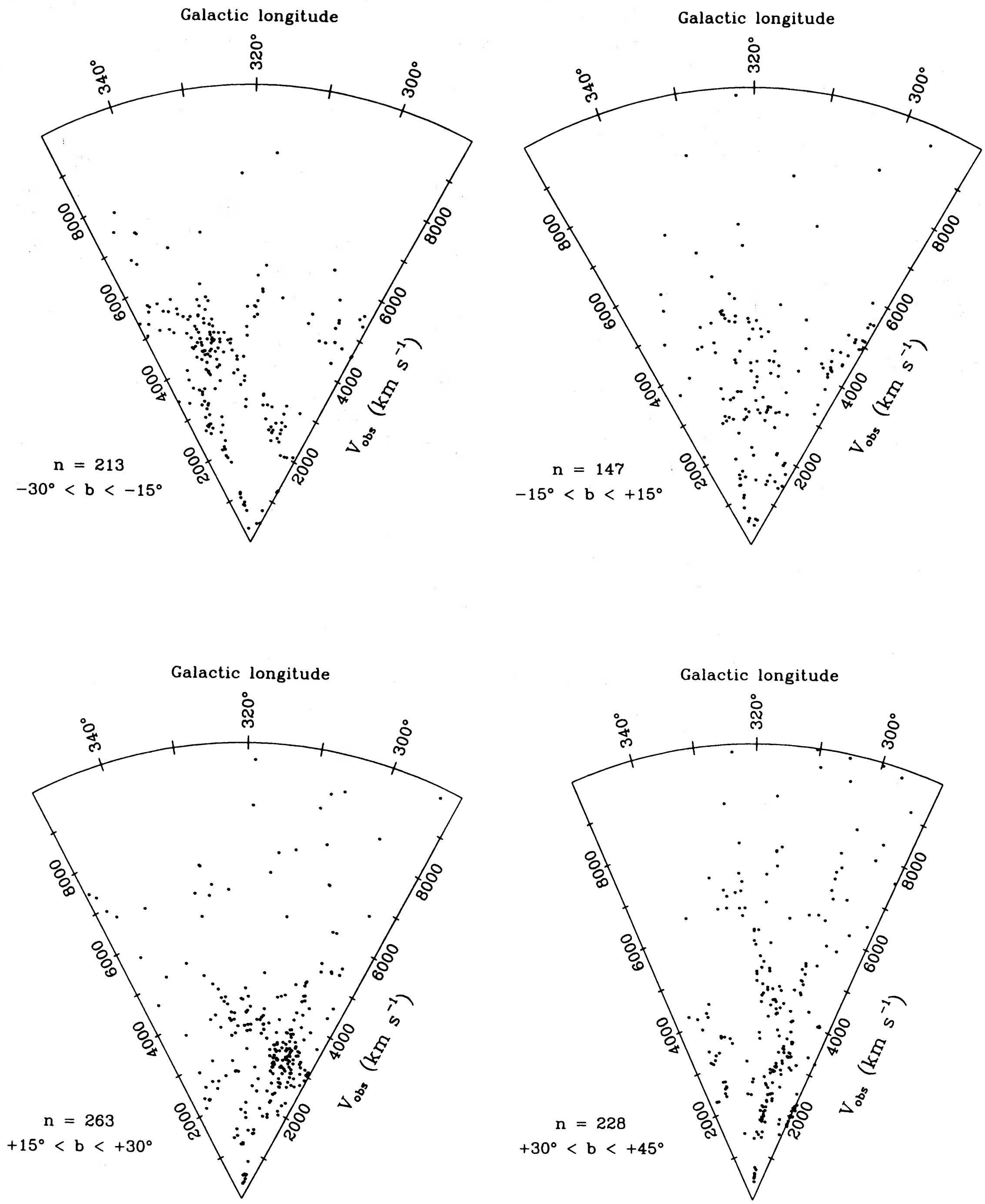

FIG. 3.—(*a*)–(*d*) " Pie diagrams " for four zones of Galactic latitude, described in the text

such large fluctuations and neither does the CFA survey, whose depth it was designed to match (see Fig. 4 of da Costa *et al.*). Neither the SSRS or CfA survey, which together cover ~40% of the sky, contain an overdensity as prominent as seen in the SPS. In view of the expected fluctuations, it may be a statistical accident that the redshift distributions of the SSRS and CfA surveys agree as well as they do. For lack of a better alternative, however, I proceed assuming that the SSRS is a representative sample and thus provides a normalization of the velocity histogram for a uniform distribution of galaxies sampled by the SPS selection criterion. Further discussion of the problem of normalization is found in § IV.

In order to minimize the effect of expected fluctuations in the normalizing distribution, a smoothed version of the SSRS has been constructed. This distribution (shown as the dotted curve in Fig. 2) has been used in the analyses that follow, although the results are very similar if the raw histogram itself is used. The smoothed distribution was constructed by convolving the histogram, binned at 400 km s^{-1} intervals, with a Gaussian of width $\sigma = V/2$ for $V < 4000$ km s^{-1} and $\sigma = 2000$ km s^{-1} for

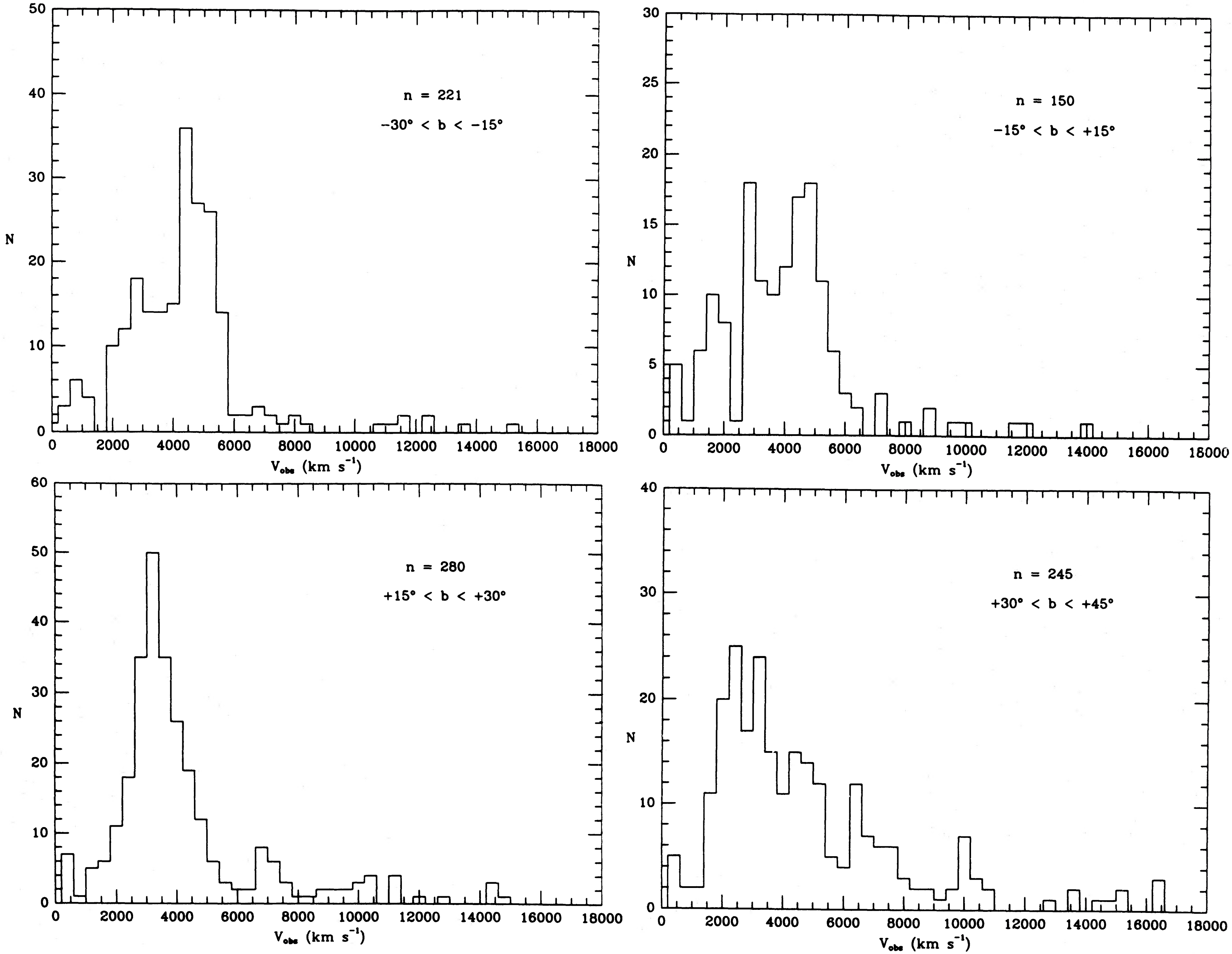

FIG. 4.—(*a*)–(*d*) Velocity histograms for the four regions shown in Fig. 3

$V > 4000$ km s^{-1}. At the distance of the concentration seen in Figure 2 the smoothing is over a very large scale (FWHM $\sim$ 5000 km s^{-1}), comparable to the largest structures seen by deLapparent *et al.* and Kirshner *et al.* (1987).

Correcting for the solar motion relative to the MWB, adopting a peculiar motion of the Centaurus supercluster of 1000 km s^{-1}, and assuming that the farther concentration is at rest with respect to the MWB, one finds "true" velocity distances of $\sim$2500 and $\sim$4500 km s^{-1} for the two peaks. Over this range there is a $\sim$40% decline in the smoothed SSRS distribution of Figure 2 and the *volume* for which this density excess applies rises by $(4500/2500)^2$. Together these two effects and the ratio of the two peaks suggest that the more distant one contains a factor of $\sim$4 more galaxies with, presumably, 4 times the mass. The centroid of the entire distribution is at $V \sim 4000$ km s^{-1}. (This estimate also assumes that both structures continue behind the Galactic plane at the average density of the unobscured region of each redshift slice.)

This first result is in good agreement with the prediction of the Lynden-Bell *et al.* model: there is an overdensity of galaxies whose centroid at $V \sim 4000$ km s^{-1}. The data also indicate that the more distant concentration dominates the kinematics of the nearer one, which makes plausible a model in which the Centaurus supercluster has acquired a large peculiar velocity due to acceleration by the former. However, for a spherical model, these numbers imply that the Local Group's peculiar motion is the result of comparable decelerations produced by *both* structures. If so, a velocity field would result that is clearly distinguishable from that arising from a single, more distant attractor. The quadrupole terms in the solution for local velocity fields for both spiral and elliptical galaxies may already be marginally able to discriminate between the two possibilities (see, e.g., Lilje, Yahil, and Jones 1986).

b) *Is the Density Enhancement the Great Attractor?*

The peak in the velocity histogram shows that the luminosity enhancement seen on the sky is primarily composed of galaxies with $V = 4000 \pm 1000$ km s^{-1}. The direction and distance of this structure agree well with the model constructed to explain the peculiar motions of elliptical galaxies. It remains to be shown, however, if the *amplitude* of this structure is sufficient to explain the peculiar velocity field, i.e., is it the "great attractor"? The best way to answer this question is to extend the map of peculiar motions beyond the structure and look for the full deceleration field. Lacking data to do this, I resort to estimating the magnitude of the overdensity in the putative great atttractor and comparing it to Local Supercluster, a structure in which the full signature of gravitational deceleration has already been mapped. As in the previous section, one must proceed with some caution because measurements of overdensity depend on knowing the average density over a region much larger than the region under study. The following determinations, then, should be taken as provisional estimates using the best available normalizations.

Aaronson *et al.* (1982) show convincingly that the Local Supercluster is responsible for a deceleration of the Local Group toward the Virgo cluster. At the position of the Local Group, the deceleration field has an amplitude of $\sim 250 \pm 50$ km s^{-1} [see also Davis and Peebles (1983) and Dressler (1984) for reviews]. In the linear regime a spherically symmetric mass distribution generates a velocity perturbation $V_{\rm pec}/V_{\rm Hubble}$ directly proportional to the density excess $\Delta\rho/\bar{\rho}$ (Peebles 1976; Gunn 1977). Davis *et al.* (1980) have estimated (from galaxy counts) $\Delta\rho/\bar{\rho} = 1.9 \pm 0.2$ for the Local Supercluster within a sphere centered on the Virgo Cluster of radius $V_{\rm Hubble} = 1350$ km s^{-1} reaching to the Local Group. Adopting for the case of the great attractor a value of $V_{\rm pec} = 550 \pm 100$ at a distance of $V_{\rm Hubble} = 4000$ km s^{-1} therefore implies, by a simple scaling to Local Supercluster, $\Delta\rho/\bar{\rho} = 1.4 \pm 0.3$.

It is relatively easy to compare this prediction with the SPS data of Figure 2, which gives ρ (SPS) and $\bar{\rho}$ (SSRS) as a function of distance from the Local Group. A slight complication is that the survey samples most but not all of this volume. For the present it is assumed that the density excess continues into the unsurveyed volume for each slice in velocity. Observations by Hopp and Materne (1985) showing that the 4000 km s^{-1} peak remains prominent all the way to the Hydra and Antlia clusters, and SSRS data indicating the same for $b < -30°$, favor this model over one where the densitiy falls rapidly. Integration over a sphere of 4000 km s^{-1} radius centered at a distance of 4000 km s^{-1} in the direction $l = 320°$, $b = 7°$ gives a value of $\Delta\rho/\bar{\rho} \approx 1.5$. This good agreement of the data with the scaling to the Local Supercluster suggests that there is sufficient mass in the structure to be the great attractor. Of course, this simple argument assumes that, for both the Local Supercluster and great attractor, these are the dominant sources of gravity over the domain in question (i.e., other exterior concentrations are more-or-less uniformly distributed). This, in turn, is related to the question of whether the SSRS provides a reliable normalization. Also, because galaxy counts, which measure $\Delta L/L$, have been taken as indicative of $\Delta\rho/\bar{\rho}$, it has been assumed that the ratio of luminous to nonluminous matter is the same for the two structures.

A similar calculaion which samples only the volume surveyed shows that the sphere of radius 3000 km s^{-1} centered at a distance of 4000 km s^{-1} contains an average overdensity of $\Delta\rho/\bar{\rho} = 2.1$. With an overdensity like that of the Local Supercluster, but a radius over twice as large, the great attractor has a mass at least an order of magnitude greater, in rough agreement with the Lynden-Bell *et al.* model. This mass of several times 10^{16} solar masses is comparable to that of other large superclusters, but an interesting difference is that this structure contains no very rich clusters of galaxies (unless one or more are hidden behind the Galactic plane.) If attention has been called to other superclusters primarily by their knots of rich clusters, the great attractor may be an example of a common yet largely undiscovered class of superclusters.

c) *Estimates of the Cosmological Density Parameter*

The technique just described can be used to estimate Ω, the ratio of the average density of the universe to the closure density, subject to the same assumptions about the correctness of the density normalization and the extent to which light traces mass. Yahil (1985) gives an approximate analytical formula for Ω which includes a correction for nonlinear growth

$$\Omega^{0.6} = 3[V_{\rm pec}/V_{\rm Hubble}][\delta]^{-1}[1 + \delta]^{0.25} , \quad (2)$$

where δ is the density excess $\Delta\rho/\bar{\rho}$. Viewed from the Local Group the centroid of the great attractor lies at $\sim$4000 km s^{-1} and the sphere of the same radius has $\Delta\rho/\bar{\rho} = 1.5$. Taking $V_{\rm pec} = 550 \pm 100$ km s^{-1} gives $\Omega = 0.17 \pm 0.05$. For comparison, the value of Ω obtained from the Local Group's infall into the Local Supercluster is also 0.1–0.2 (Yahil 1985).

At first glance this seems like evidence against the notion that Ω increases with scale, as is expected in models with "biasing" where luminous matter is more clustered than dark matter. However, a further application of the SPS data throws doubt on this conclusion. If Ω is ~ 0.2, a peculiar motion of ~ 900 km s^{-1} for the Centaurus Cluster implies an overdensity of ~ 5–6 for the sphere of radius 2000 km s^{-1} centered on the more massive concentration of the great attractor. In fact, the SPS survey indicates a much lower value of $\Delta\rho/\bar{\rho} \sim 3$, which implies $\Omega \sim 0.5$. This is disturbing because (1) Ω values calculated from the smaller scale would only be higher in the case of *antibiasing*, and (2) the result does not agree with that for the Local Supercluster, which samples a similar scale. There are several possible resolutions of this discrepancy. The galaxy distribution function of Figure 2 indicates that there is an underdensity between the Local Group and Centaurus, which will have the effect of pushing the Centaurus velocity higher than the overdensity would alone. Furthermore, if the Centaurus velocity were as low as 700 km s^{-1}, marginally within the errors of the Lynden-Bell *et al.* data, the implied Ω would be only 0.3. This is compatible, within the uncertainties, with the value inferred from the Local Group motion. Furthermore, the crucial region of the sphere affecting Centaurus is behind the Galactic plane, so it is at least possible that a significant rise in the density of galaxies is hidden from view. Departures from spherical symmetry might also be important in this case.

Although any one or a combination of these effects might make the peculiar velocity of Centaurus compatible with a low Ω, this example points up the limitations of the simple spherical infall mode.. The assumption that matter *outside* the sphere is distributed *uniformly*, and thus has no effect, is probably unjustified considering the complex structure seen in maps of the large-scale galaxy distribution. This point has been made by Villumsen and Davis (1986), who use numerical simulations to show that *local* variations from spherical infall models can be very large. It is possible, then, that the low Ω derived from the Local Group's motion toward the great attractor is seriously underestimated because the pull of the Perseus-Pisces supercluster (Giovanelli, Haynes, and Chincarini 1986), an important overdensity at a distance similar to the great attractor but on the opposite side of the sky, has reduced the Local Group's motion. A void between the Local Group and Centaurus, though a less prominent fluctuation, could also have a large effect due to its proximity. The Local Group's motion toward the Virgo Cluster might similarly be influenced by other local fluctuations in the galaxy distribution.

It would seem that values of Ω measured by the procedure of isolated spheres in a uniform background are quite uncertain. More useful values will be available when the galaxy distribution and peculiar velocity field are well-specified over a volume larger than the scale that is being attempted. Until such data are available, about all that can be concluded is that motions induced by luminous overdensities are generally too small to be consistent with $\Omega \sim 1$. Even this conclusion must be qualified, however, since it is based on the assumption that light is an unbiased tracer of mass. The quoted "overdensities" are, in fact, "overluminosities." Assuming these to be equivalent ignores the possibility that mass in the universe is less clustered than the light, and that, as a result, values of Ω measured in this fashion will be consistently underestimated.

IV. SUMMARY AND DIRECTIONS OF FUTURE RESEARCH

Peculiar velocities comparable to that of the Local Group have been found for ellipticals over a large volume of space. This indicates that the Local Group motion with respect to the MWB is due to the gravitational pull of a substantial overdensity beyond the H-C supercluster. A model capable of explaining the velocity field predicts a direction and mass, and a map of the galaxy distribution has revealed an apparent galaxy excess in the proper direction. Although the SPS survey is only 64% complete, it has taken the next step by showing that the galaxy excess is due to a coherent though complex structure whose centroid lies at the approximate distance predicted by the flow model.

Section III*b* of this paper is an attempt to go further and show that not just the location but also the *amplitude* of the overdensity is also that predicted by the model. As discussed, such a demonstration is more difficult because density fluctuations with large amplitudes over large scales complicate attempts to find the mean density. Nevertheless, this attempt has been made assuming that the SSRS provides the needed representative sample. As mentioned earlier, the good agreement of the SSRS and CfA surveys add some confidence to this approach. Furthermore, it is important to realize that an estimation of the velocity component induced by the great attrator, scaled to that generated by the Local Supercluster, requires only the *local* density normalization ($V \lesssim 6000$ km s^{-1}). The SSRS, SPS, and CfA surveys have already sampled about half of the unobscured 10 sr, so it seems likely that this local normalization is not greatly in error. Put another way, the density of the local universe is whatever it is, and peculiar motions arise solely because of the *relative* importance of the fluctuations. Assuming that the SSRS and CfA surveys have measured the mean density to better than $\sim 30\%$, the SPS data imply that the great attractor, which is composed both of the previously identified Hydra-Centaurus supercluster and a more distant, more massive concentration, is more than an order of magnitude more prominent than the Local Supercluster. This makes plausible the model that the great attractor has generated a peculiar motion of ~ 500 km s^{-1} if the Local Supercluster has induced a ~ 250 km s^{-1} motion.

This situation is somewhat different from the measurement of a *global* Ω, which requires further information on whether the local normalization applies to even larger scales. Thus, for example, we might live in a region of lower density in which values of *local* Ω are low, yet the global value might still be unity. If we live in a region which is underdense by a factor of ~ 5, the low values of Ω found in § III*c* would imply that the universe is near critical density, as is favored by inflationary universe models. There are no data supporting the notion that the local universe is underdense, but it is difficult to rule out with existing samples. In view of this and the limitations of spherical models, discussed previously, it would seem premature to conclude too much concerning the global value of Ω from these kinds of studies.

Although the SPS is an important step in identifying the great attractor, it is clearly not the final one. This requires demonstrations that (1) galaxies in the ~ 4000 km s^{-1} concentration have small peculiar motions with respect to the MWB; (2) galaxies just beyond are "falling in" from the other side; (3) there exists a more distant reference frame that is at rest with respect to the MWB (see Aaronson *et al.* 1986). It is also necessary to finish surveying the galaxy distribution in all directions out to $V \sim 6000$ km s^{-1} in order to make a compelling case for the origin of the Local Group's peculiar motion. The CfA and SSRS surveys have already done this for the north and south Galactic caps and they show no competitors to the large overdensity described here. Approximately

6 sr within 30° of the Galactic plane, about one-third of which is obscured by dust, have not been surveyed systematically. One known overdensity in this area, the Perseus-Pisces supercluster (Giovanelli, Haynes, and Chincarini 1986), lies on the opposite side of the sky from the great attractor, with a similar distance and perhaps a comparable mass. Confirmation of the model presented here requires a survey and analysis of the Perseus region which demonstrates that this supercluster should not offset the pull of the great attractor. The void in front of the Perseus-Pisces supercluster may be crucial in this connection.

Finally, even with the pull of the great attractor and the Local Supercluster, a significant component of the Local Group's motion is left unexplained (Lynden-Bell *et al.*). This may be related to measurements of the *IRAS* dipole anisotropy (Strauss and Davis 1987; Villumsen and Strauss 1987), which imply that much of the Local Group's motion is induced *within* the Local Supercluster. More complete galaxy distributions and maps of peculiar velocity fields are required to answer such questions and resolve the inconsistencies.

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