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# Mapping the Local Structure

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**Abstract.** A database of 30,000 galaxies within a cube $\pm 8,000$ km s$^{-1}$ centered at our position is used to illustrate the properties of the nearby structure in the distribution of galaxies. The data cube can be manipulated in ways that enhance the visualization of the structure with special software. The dominant regions of high density are the Great Attractor, the Great Wall, and the Perseus-Pisces complexes. There are many voids.

## 1. The 8K Catalog

The accumulation of galaxy redshifts in order to study the structure in the distribution of galaxies has been a major industry over the last two decades. In spite of this great effort, few astronomers have much sense of the structure that surrounds us. We live in what de Vaucouleurs (1958) called the Local Supercluster, which improvements in our knowledge have successively revealed is part of a larger Hydra-Centaurus-Virgo complex, in turn part of a nebulously defined 'Great Attractor' region.

The present contribution represents an attempt to familiarize the audience with the morphology of this local region. The talk cannot adequately be transferred to the pages of a book because the presentation involved manipulation of an interactive computer display. The software 'partiview' developed by Stuart Levy, National Center for Supercomputing Applications, University of Illinois (http://www.haydenplanetarium.org/hp/vo/du/partiview.html) permits rotations, zooms, highlighting, and other tricks that help develop a familiarity with the complex nearby structure. Some of these features can be seen in a web VRML display at the URL http://www.ifa.hawaii.edu/~tully if one clicks on the highlight 'Manipulate a data cube of 30,000 galaxies'. This VRML display was developed by Paul Bourke, Swinburne University. Other related material can be reached at the Hawaii URL by clicking on 'Large Scale Structure'.

A few words are in order regarding the database. The primary source is John Huchra's ZCAT (http://cfa-www.harvard.edu/~huchra/zcat/zcom.htm). This compendium includes information from all possible sources of redshift information, based on all imaginable selection criteria. Most of the contributions originate from selection based on optical images. However, there are contributions that range from blind HI selection (Meyer et al. 2004) and far infrared selection (PSCz: Saunders et al. 2000) that favor spiral and generally late-type galaxies to near infrared (Jarrett et al. 2000) and X-ray selection (Ebeling, Mullis, & Tully 2002) that favors ellipticals and generally early-type systems.



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If one considers a sample from ZCAT that extends to a high redshift then there would be gross angular inhomogeneities caused by the predominant contributions from pencil beam or strip searches; receiving inputs like the Las Campanas, 2dF, and Sloan surveys. In fact the catalog that we call 8K (which is limited by a box of radius 8,000 km $s^{-1}$ on the cardinal axes) was restricted by the appreciation of the increasing importance of such angular artifacts with redshift. Within 8,000 km $s^{-1}$ the problem is less severe because the sample is dominated by such wide angle surveys as CfA2 (ZCAT web page and Falco et al. 1999), SSRS2 (da Costa et al. 1998), and ORS (Santiago et al. 1995). These surveys ensure the inclusion of all galaxies to a bit fainter than $L^\star$ out to the velocity limit. Consequently the correction for missing light is modest (rising from unity to a factor 2.5 at 8,000 km $s^{-1}$) and does not have a substantial angular dependence out to this limit. Of course, these comments do not apply at low galactic latitudes where incompleteness remains. However HI, infrared, and X-ray selected surveys are minimizing the low-latitude problem. The 8K catalog has a faint level clip at $M_B = -15$.

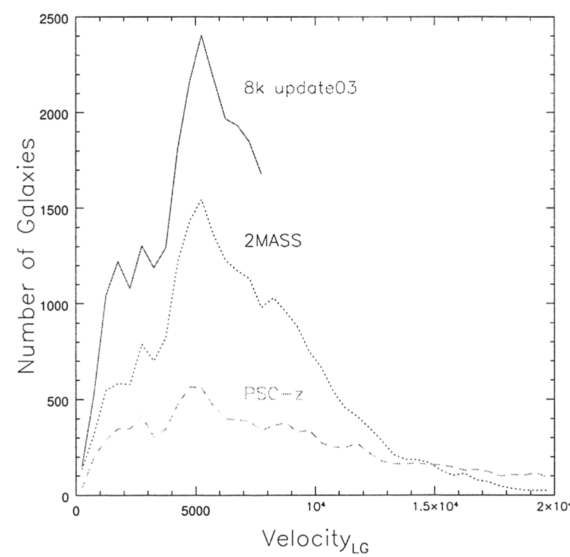


Figure 1. Number of galaxies as a function of systemic velocity for 3 surveys. Dashed curve: far-infrared selected PSC-z survey; dotted curve: near-infrared selected 2MASS survey; solid curve: the 8K compendium.

Though the 8K catalog is not as rigorously defined as other samples, it does have the virtue of greater density of information (galaxies/$Mpc^3$) than any other galaxy compendium. Figure 1 provides a comparison with two other all-sky surveys: 2MASS $K < 11.25$ redshift survey (Huchra et al. in preparation) and PSCz (Saunders et al. 2000). All three samples have similar range, with velocity histograms that peak at 5,000 km $s^{-1}$ and some coverage out to 20,000 km $s^{-1}$. However the density of objects in 8K is over 4 times that in PSCz and 60% higher than in 2MASS at the $K = 11.25$ cut.

## 2. Views of the Local Supercluster

The following three figures provide an overview of the structure in our immediate vicinity. They represent a face on, polar, and end on view of the region in a box that encloses the main components of the Local Supercluster in the north Galactic hemisphere and extending out to the domain of what has been called the Great Attractor.

Our Galaxy is located on one face of the box and the plane of obscuration basically lies on that face. So the view in Figure 2 is from our perspective with our nose pressed up to the surface of the box. The supergalactic coordinate system is used in this figure and the following. This coordinate system is the natural one for this region of space because it is aligned orthogonal to the dominant filamentary structures. The equatorial plane of the supergalactic coordinate system runs horizontally across the middle of Figure 2. There is a strong concentration of galaxies to this equatorial plane of the supergalactic coordinate system (indeed, this concentration largely defines the coordinate system). The Virgo Cluster is the densest concentration of objects near the center of the field. Two other rich clusters in the Great Attractor direction are identified: the Centaurus Cluster and the Hydra I Cluster. Note the particularly prominent filament that runs down from the Centaurus Cluster to close projected proximity to the Hydra I Cluster.

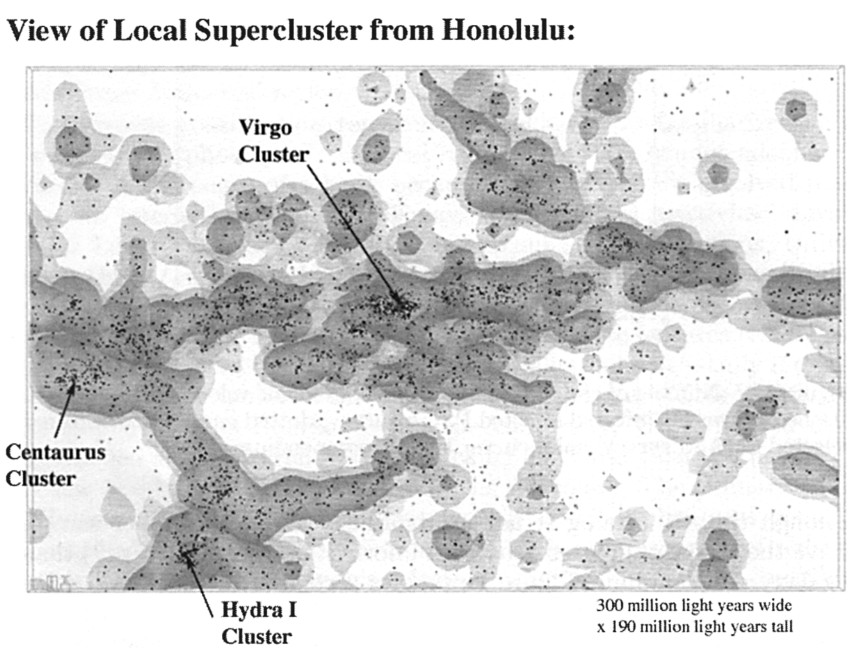


Figure 2. Face-on view of the Local Supercluster, looking toward the North Galactic Pole.

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The same scene is shown from the north pole of the supergalactic coordinate system in Figure 3. Our location is identified on the lower boundary. We lie on a spur that runs to the main left-right feature of the plot. The Virgo and Centaurus clusters lie within this feature, with Hydra I slightly behind. By comparing this figure with the previous one, it can be seen that this dominant feature of Figure 3 is not a single filament but rather is the compound of two filamentary structures seen in Figure 2; one running in the equatorial plane from Centaurus to Virgo and the other running down from Centaurus to the foreground of Hydra I.

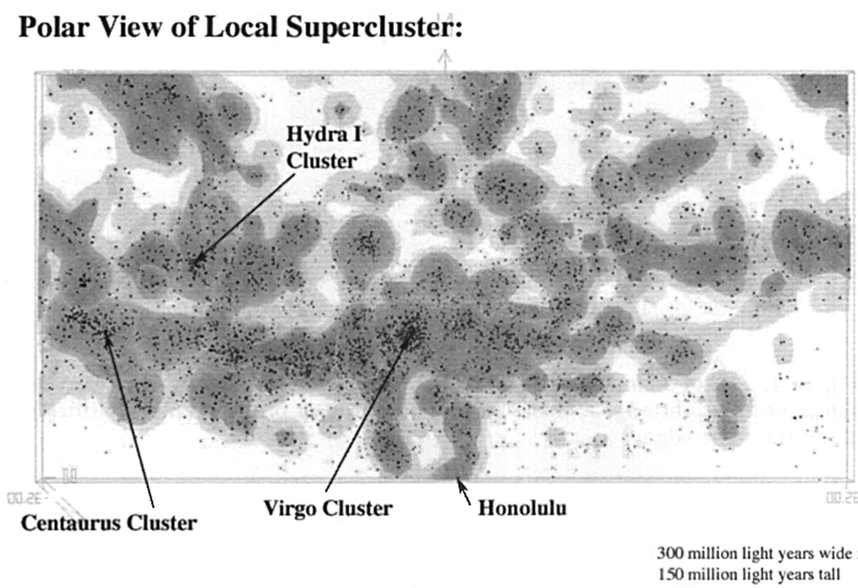


Figure 3. Polar view of the Local Supercluster. Our Galaxy is near the center on the bottom edge and the zone of obscuration projects along the bottom edge.

The tour of the local region is completed with the end on view of Figure 4. We are looking in from the left sides of the previous figures, the end in the proximity of the Great Attractor. Home is located on the right edge. Virgo and Centaurus clusters lie within a common vertical wall-like structure, though the previous figures have taught us that the wall is more like a series of filaments. Hydra I lies somewhat behind. The other prominent feature of Figure 4 is the horizontal band of galaxies on the supergalactic equatorial plane.

## 3. Superclusters and Voids

There is still no clear definition of what is meant by the term 'supercluster'. The cosmic web of filaments seems endlessly interconnected. Morphologies vary from

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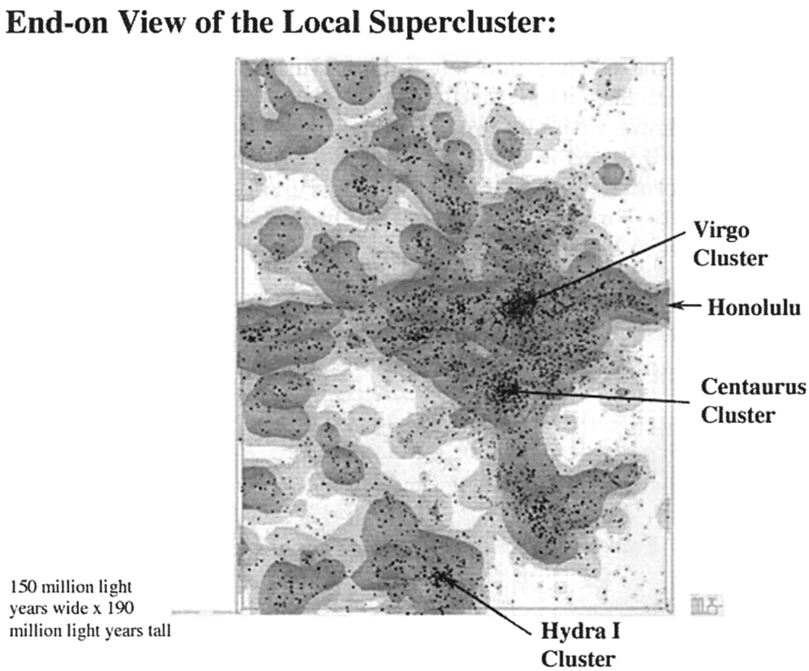


Figure 4. End on view of the Local Supercluster. Our Galaxy lies near the center on the right edge and the zone of obscuration projects (slightly tilted) along the right edge.

surfaces shaped liked a cupped hand or the fragment of an eggshell to arteries that curve and branch. Perhaps a supercluster can be defined as the structure lying within a density surface at a saddlepoint value below the universal mean. It remains to be seen if a single density can be defined that makes general sense. Within the 8K data box there are three major structures we view as distinct (our Great Attractor, the Great Wall, and the Perseus-Pisces structure) but only the first of these is entirely contained within the boundaries of our sample. Even this structure is inadequately explored because important components lie at low Galactic latitudes.

Then there are voids — lots of voids. Wherever there is structure there are voids all around. Exit from the Local Group toward the north supergalactic pole and one is instantly in the Local Void. This empty region with a near edge at 1 Mpc can be seen from the HIPASS survey to extend to 6,000 km $s^{-1}$! Another huge void occupies most of the high latitude sky behind what de Vaucouleurs called the Southern Supercluster at 1,000 km $s^{-1}$ and extends to 7,000 km $s^{-1}$. On the plane of the sky the void extends at least 8,000 km $s^{-1}$.

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