TRACING SUPERCLUSTERS AND VOIDS WITH ABELL CLUSTERS

Jack O. Burns
Institute for Astrophysics, Univ. of New Mexico
Albuquerque, NM 87131 USA

David J. Batuski
Space Telescope Science Institute, Homewood Campus
Baltimore, MD 21218 USA

ABSTRACT. The structure within the distribution of rich clusters is described. In particular, the Pisces-Cetus region is shown to contain a dense supercluster, a 300 h_{75}^{-1} Mpc long filament of galaxies and clusters, and a ring of 12 Abell clusters surrounding a $\approx$ 50 h_{75}^{-1} Mpc diameter void.

Rich clusters of galaxies such as those found in Abell's catalog may serve as important tracers of the large scale distribution of luminous matter in the Universe. In principle, such clusters allow us to efficiently and rapidly sample a much larger volume and, therefore, larger scale sizes of structure than is currently possible in magnitude-limited galaxy redshift surveys. Recently, there have been suggestions of some extremely large (>300 Mpc) supercluster structures composed of Abell clusters linked by low density chains of galaxies (Batuski and Burns, 1985a) and voids defined by the absence of rich clusters (Bahcall and Soneira, 1982; Batuski and Burns, 1985b). One general question remains: how accurately do these clusters trace the distribution of matter?

Two approaches to this problem have been taken. First, one can examine this question using the 2-point spatial correlation function for rich clusters (Bahcall and Soneira, 1983). Confusion becomes immediately apparent, however, in noting that the amplitude of this function depends upon richness (Bahcall, 1987). The origin of this effect is still unclear at present. The relationship between clusters and galaxies becomes clouded by this richness effect. More important, however, is to note that the 2-point function cannot provide a complete description of the connectedness of Abell clusters. Batuski and Burns (1985b) have shown that there is much more large scale structure in the multiplicity function of superclusters composed of Abell clusters than in random distributions of pseudo-clusters constrained to follow the 2-point function. Thus, we conclude that the 2-point function is an inadequate tool to address this question.

A. Hewitt et al. (eds.), Observational Cosmology, 319–322.

Second, a more useful approach that we have undertaken is to identify regions that are overdense in Abell clusters using a percolation scheme, then follow-up on these candidate superclusters with redshift observations of individual galaxies within and between clusters. In this way, we directly address the physical connectedness of rich clusters. We have published the more extensive catalog to date of Abell cluster structures composed of 102 candidate superclusters and 29 candidate voids with $z \lesssim 0.13$ (Batuski and Burns, 1985b).

As an example of the structure seen within these superclusters, we show in Fig. 1 the Pisces-Cetus region containing a dense collection of rich and poor clusters from Batuski and Burns (1985a). This supercluster contains 36 Abell clusters with redshifts ranging between 0.03 to 0.08 (all of which are measured). This region is 5 times denser in rich clusters than the average found in Abell's catalog. The full range of large scale structures is represented here. There is a filament of clusters shown by the dashed contour in Fig. 1 that is 310 h_{75}^{-1} Mpc in length. It is the largest such structure presently known. The filament is traced well by both Abell and Zwicky clusters. In the nearest 90 Mpc (Perseus-Pisces), the clusters are very tightly linked in 3-D by CfA survey galaxies. Beyond this inner portion, our recent redshift observations show that galaxies continue to follow the clusters. Statistically, the filament is unlikely to be a chance 3-D alignment of clusters at the 0.3% probability level.

On either side of the filament are $\sim$80 h_{75}^{-1} Mpc and $\sim$120 h_{75}^{-1} Mpc regions that are devoid of clusters. They provide definition to the filament. Except for the volume nearest Perseus, the filament and void structures are not seriously affected by galactic obscuration.

At the heart of the densest portion of the Pisces-Cetus supercluster (near A189 and A195), we have also found a very interesting structure of clusters and galaxies. As shown in Fig. 2, a ring of 12 Abell clusters surrounds a region that is significantly underdense in galaxies. This structure is present in both the 2-D distribution of Zwicky galaxies and in the 3-D Cfa survey. The ring is tilted with respect to the plane of the sky oriented such that A400, A194, and A397 are closer to us than the remaining portion. There is also complex redshift structure within a "nest" of clusters to the south of the void. The structures seen here must still be viewed as tentative because of the limited galaxy redshifts presently available.

We conclude that in the Pisces-Cetus region and other candidate superclusters described by Batuski and Burns (1985b), there are highly interesting 50-300 h_{75}^{-1} Mpc sized structures illuminated by Abell clusters. Our work to date provides considerable evidence that rich clusters are good tracers of the galaxy distribution. Therefore, Abell clusters appear to provide an extremely useful tool for mapping the largest structures in the Universe.

We wish to thank J. Huchra and colleagues for providing us with some unpublished galaxy redshifts. J.O.B. was supported in this work by grants from the U.S. NSF (AST-8314558 and AST-8520115).

REFERENCES

Bahcall, N. 1987, this volume.

Bahcall, N. and Soneira, R. 1982, Ap.J.(Letters), 258, L17.

______. 1983, Ap.J., 270, 20.

Batuski, D. and Burns, J. 1985a, Ap.J., 299, 5.

______. 1985b, A.J., 90, 1413.

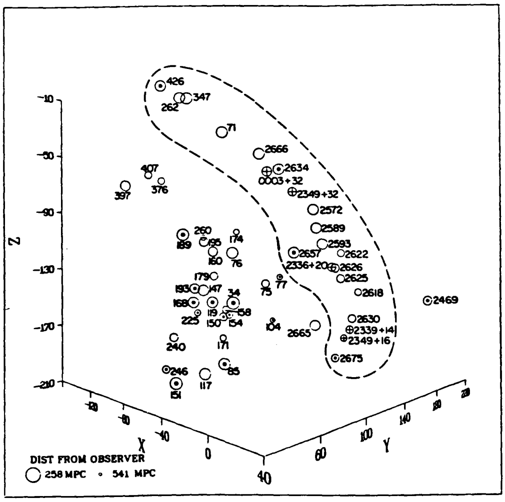
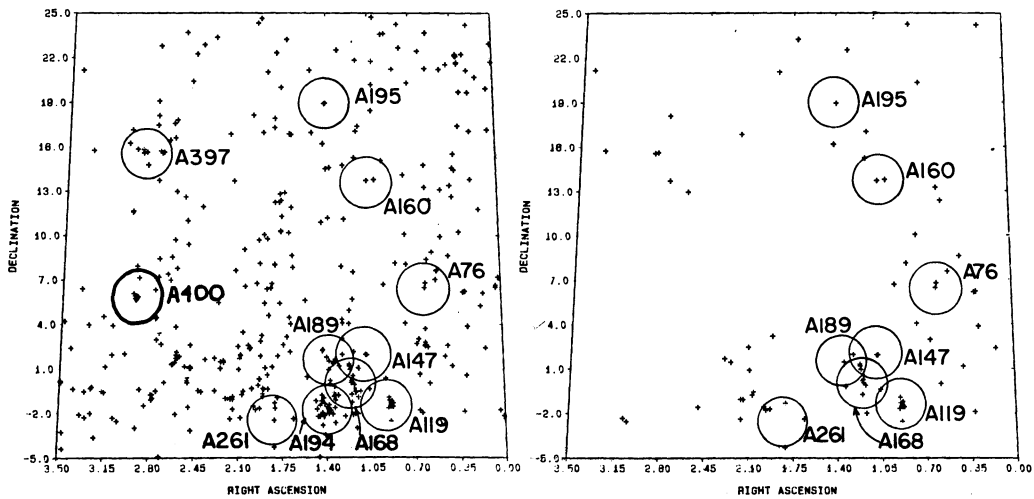


Fig. 1 - Plot of projection of the 3-D arrangement of clusters in the Pisecs-Cetus region. Units for the axes are Mpc. Earth is at position (0,0,0). Observer is 400 Mpc from the cube center. Numbers are Abell or Zwicky clusters. Note the filamentary arrangement within the dashed contour that is over 300 Mpc in length.



a) 5000-14,400 km/sec

b) 10,000-13,500 km/sec

Fig. 2 - Ring of 12 Abell clusters surrounding a 50 Mpc void of galaxies. Crosses are positions of CfA galaxies over a large (a) and smaller range (b) of velocities (distances). The ring is inclined at an angle with respect is the sky plane such that A189, A400, and A397 are closer to us. The void appears to be centered at about 12,000 km/sec. This region is near the center of Fig. 1.

DISCUSSION

KIANG: (1) I think I was the first one to suggest that the correlation length for Abell clusters may be a function of sampling volume, through a rather sophisticated model fitting method (Kiang 1966, MNRAS). (2) Saslaw and I produced a spatial correlation curve for Abell clusters, using simply the magnitude of 3rd (10th?) brightest member as distance indicator, about 20 years ago. This also showed the bump at the large separation shown in the diagram given by Batuski et al. based on extensive redshift data.

BURNS: (1) This possibility suggested again recently by Einasto et al. (1986, MNRAS), is one of several possibilities to explain the richness effect on the 2-point function. (2) This bump at ~200 Mpc (see Batuski et al. these proceedings) appears to be a significant feature in large volume samples of rich clusters. It appears consistent with recent 6-m data described by Karachentsev (these proceedings) and the appearance of galaxy sheets separated by ~200 Mpc in faint galaxy surveys (Ellis, these proceedings). At present, this bump is not reproduced in any models of large scale structure.

BAHCALL: Unless the volume studied is too small and therefore unrepresentative of the sky average, the correlation functions do not depend on the size of the sample volume. For example, several correlation functions of galaxies were determined over quite different volumes (Lick Counts, CFA Survey, Southern Surveys), all yielding essentially the same results. Similarly, samples of different objects studied over the same volume, such as the Lick galaxies, $R \geq 1$ clusters, and $R \geq 2$ clusters (Bahcall and Soneira 1983, Ap.J.) yield intrinsically different correlations.