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OBSERVATIONAL AND THEORETICAL STUDIES OF RICH CLUSTERS WITH MULTIPLE SUBCONDENSATIONS

Grant NAGW-201

Semiannual Report No. 6

For the period 1 January 1984 through 30 June 1984

Principal Investigators

Dr. Margaret J. Geller and Dr. John P. Huchra

June 1984

Prepared for
National Aeronautics and Space Administration
Washington, D.C. 20546

Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

The Smithsonian Astrophysical Observatory
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The NASA Technical Officer for this grant is Mr. Robert E. Stencel, Code EZ-7, Headquarters, National Aeronautics and Space Administration, Washington, D.C. 20546.

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Over the past six months we have continued our observational and theoretical studies of the formation and evolution of clusters of galaxies. We have also continued to explore the relationship between the properties of individual galaxies and their environment.

Several studies of individual rich clusters are complete or very nearly so. Our redshift survey of the 6^{o} core of the Virgo cluster is now complete to the limit of the Zwicky catalog: there are more than 500 galaxies with measured redshifts in the sample (Huchra et. al. 1984). Perhaps the most remarkable physical result derived from these data is the apparent substructure in redshift-position space. Both NGC4472 and M87 sit at the bottom of local potential wells (see Figure 1). The distribution of spiral galaxies is quite different from the distribution of the elliptical (Figure 2). The velocity distribution for the spirals is also substantially broader than the distribution for the ellipticals (Figure 3) - the spirals may still be infalling. We plan to complete more detailed dynamical studies in the coming year.

We have measured $\simeq$60 velocities in the x-ray cluster A1750 (Beers et. al. 1984). The cluster is actually triple in both the x-ray and in the optical. The two larger subclusters differ in mean redshift by $\simeq$1300 km s^{-1}. Application of the two-body model which we used to study A98 indicates that A1750 is probably not a single bound system.

We also have a nearly complete velocity survey of the highly flattened system A194. The published mass-to-light ratio for this system is a factor of ten below the value typical of other clusters of galaxies. We hope that a detailed dynamical study of A194 and other similarly flattened systems will yield information on the intrinsic range of mass-to-light ratios for galaxies in clusters. Our velocity data should also provide limits on the velocity anisotropy of the system. Such anisotropy limits are important for distinguishing between the isothermal and adiabatic pictures for structure formation.

Over the past several years (supported in part by NAGW-201) we have been accumulating data on superclusters as well as on the individual clusters discussed above. The simplest superclusters we could identify are those composed of pairs of Abell clusters. We have complete magnitude limited velocity surveys for some of these pairs. For others we have measured enough velocities for preliminary estimates of the relative mean velocity of the clusters and of the internal dispersion of each cluster. From these estimates we should be able to derive a new large-scale measure of the cosmological mean mass density.

We have also been studying the very rich Cor Bor supercluster. We have measured more than 100 velocities in the system and we expect to measure another hundred in late June 1984. The measurements in hand give us a velocity dispersion for each of the 6 clusters in the system and make Cor Bor one of the best studied superclusters. In addition to acquiring velocity measurement we have been mapping the galaxy distribution in the region. The clusters have markedly different morphologies: A2065 is centrally condensed and A2079 is highly flattened (Figures 4 and 5). We are now ready to make simple dynamical models of the system.

Some large statistical studies are also underway to complement the studies of individual systems. We have collected together all the redshift measurements for Abell clusters - there are now more than 500 clusters in this sample. We are using these data to study the cluster-cluster correlation function. This large data set confirms the Bahcall-Soneira detection of structure on very large scales.

PUBLICATIONS

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When Clusters are Superclusters, M.J. Geller, Comments on Astrophysics, X, 2, 47-51.

A Redshift Survey of the Cluster A1142, M.J. Geller, T.C. Beers, G.D. Bothun, and J.P. Huchra, A.J., 89, 319.

The Morphology-Density Relation: The Group Connection, M. Postman and M.J. Geller, Ap. J., 281, 95.

Seven Poor Clusters of Galaxies, T.C. Beers, M.J. Geller, J.P. Huchra, D.W. Latham, and R. Davis, Ap. J., July 1, 1984.

Groups of Galaxies, in Clusters and Groups of Galaxies (to be published by Reidel), M.J. Geller

The Core of the Virgo Cluster, in Clusters and Groups of Galaxies (to be published by Reidel), J.P. Huchra, R.J. Davis, and D.W. Latham

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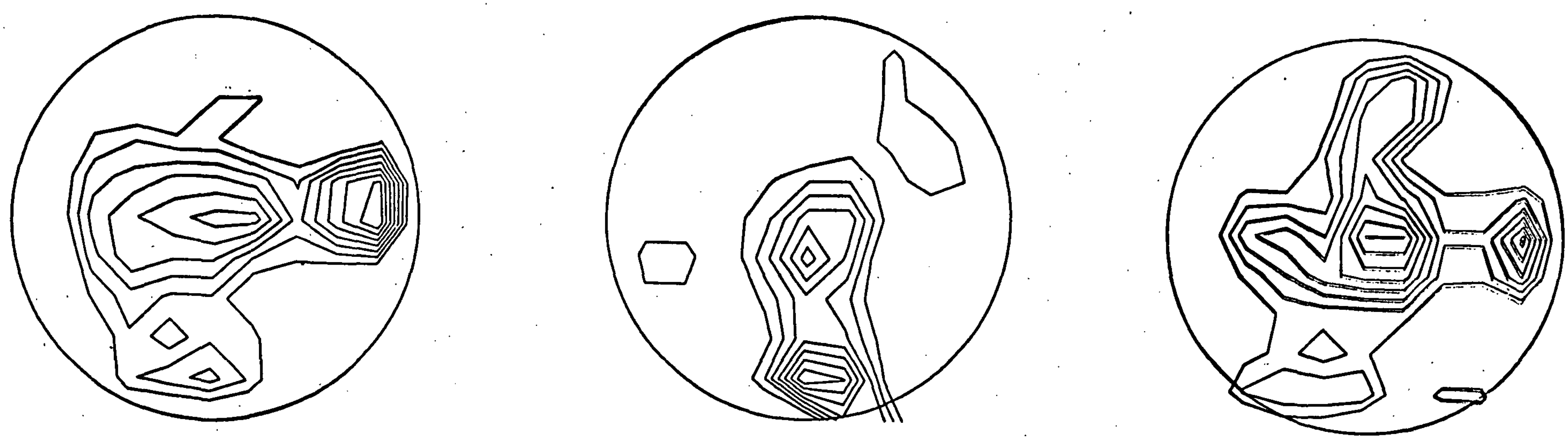
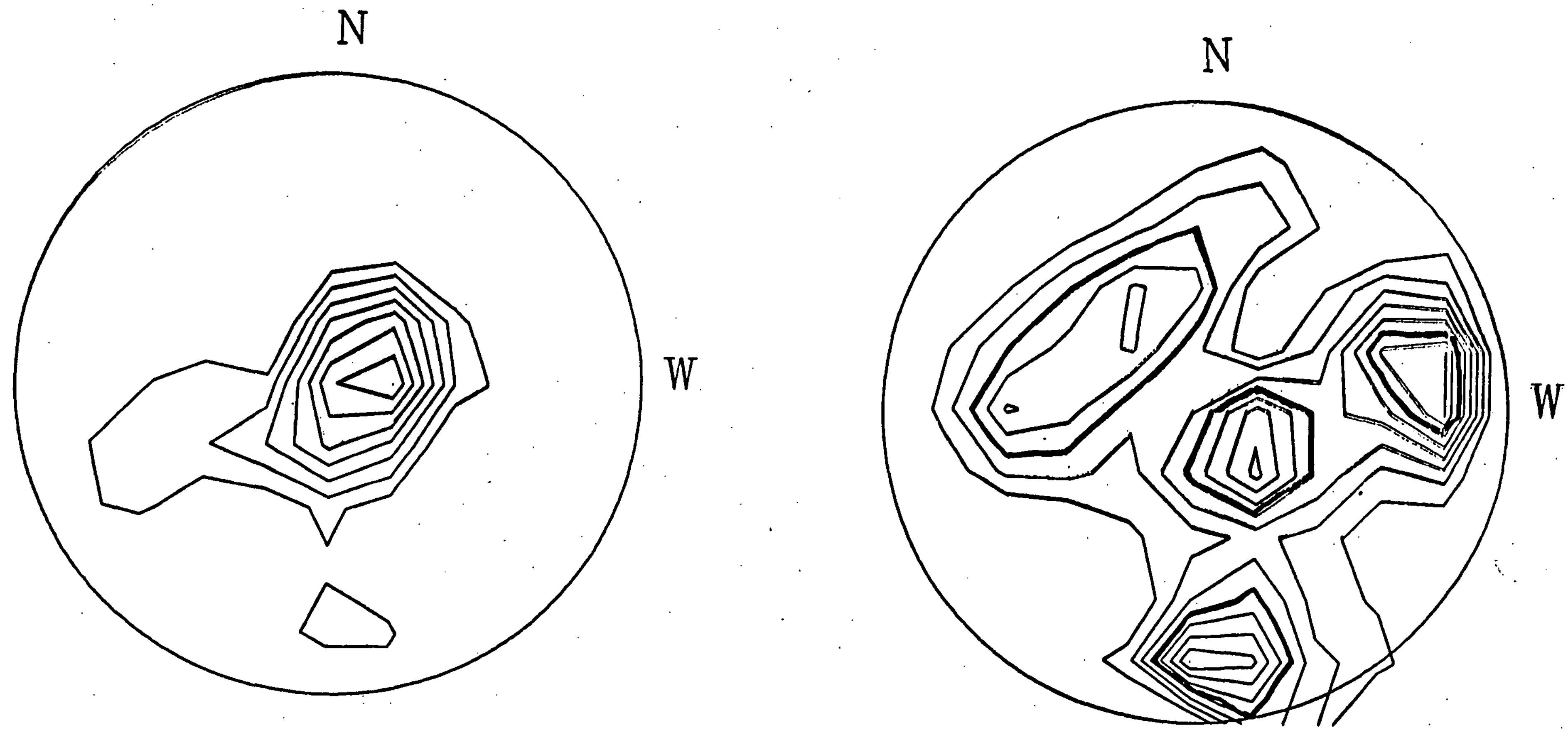


VIRGO −1000 TO 500

VIRGO 500 TO 1500

VIRGO 1500 TO 3000

Figure 1: Substructure in the Virgo core. M87 lies near the center of the circle. NGC4472 lies near the center of the southern clump. The numbers at the bottom of each contour plot give the relevant velocity range.



Cluster: VIRGO ELLIPTICALS
Bin size: 120.0 arcmin
Scale: 4.72 arcmin/mm 1° 0.3 Mpc

Cluster: VIRGO SPIRALS
Bin size: 120.0 arcmin
Scale: 4.72 arcmin/mm 1° 0.3 Mpc

Figure 2: The surface distribution of ellipticals and spirals in the Virgo core

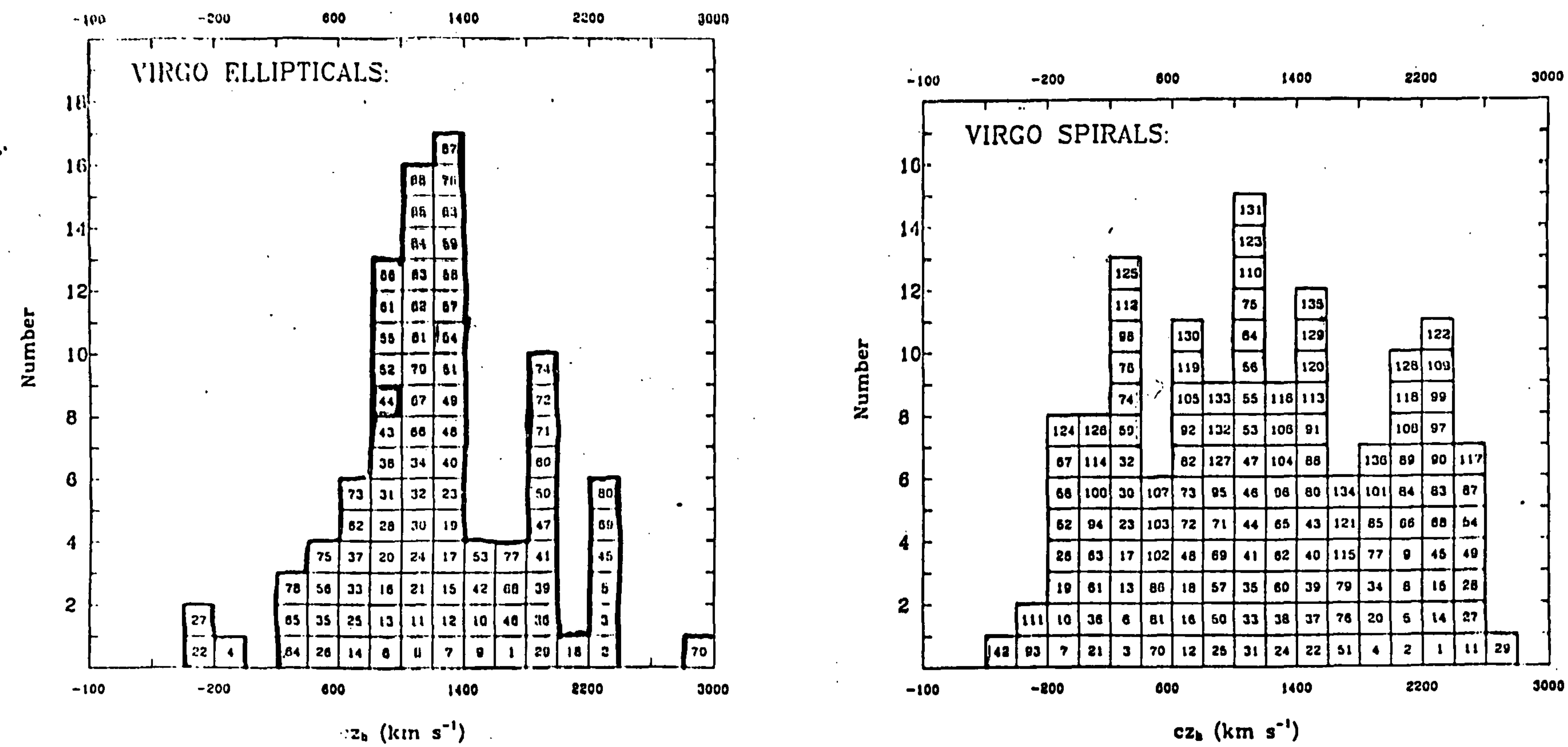
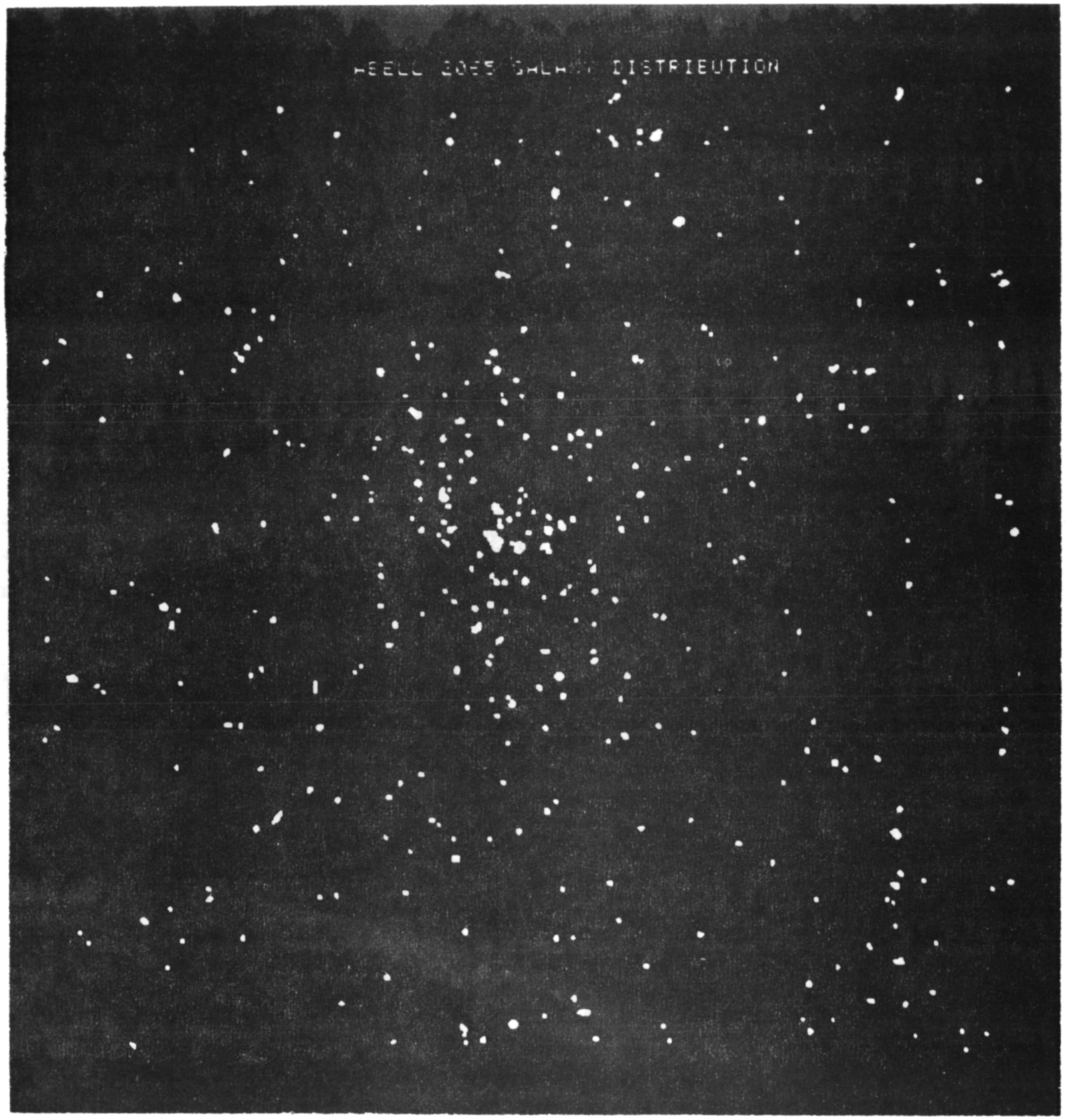


Figure 3: The velocity distribution for ellipticals and spirals in the Virgo core.

SOUTH



WEST

Figure 4: The galaxy distribution in the rich cluster A2065

SOUTH

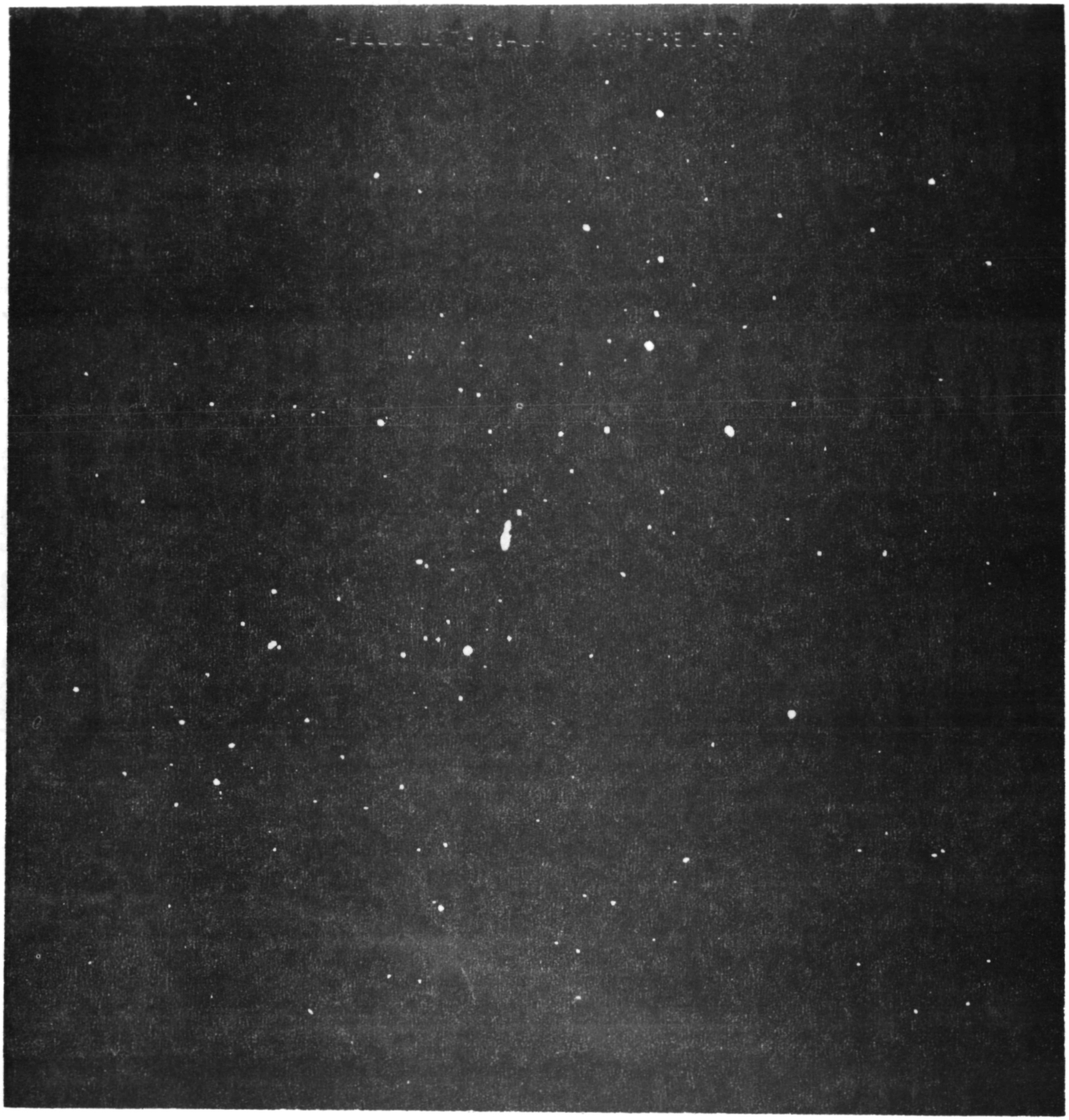


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Figure 5: The galaxy distribution on A2079. This cluster and A2065 are both in the Cor Bor supercluster.

FIGURE 12: MIRROR BRDF CHARACTERISTICS

APPENDIX B