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THE COMA SUPERCLUSTER: ANALYSIS OF ZWICKY-HERZOG CLUSTER 16 IN FIELD 158

GUIDO CHINCARINI*
Department of Physics and Astronomy, University of Oklahoma
AND
HERBERT J. ROOD*
Department of Astronomy and Astrophysics, Michigan State University
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ABSTRACT

Radial velocities for 50 of the 52 galaxies brighter than 15.1 mag within the boundaries of Zwicky-Herzog cluster 16 in field 158 are used to establish that the region is a composite of (i) part of the Coma I cloud of the Local Supercluster, (ii) part of the supercluster of which the Coma cluster is a member, (iii) the NGC 4169 group, and (iv) other galaxies. The Coma supercluster is detected to a radial distance from the center of the Coma cluster of 14°.2 (31.5 Mpc for $H = 55$ km s^{-1} Mpc^{-1}).

Subject headings: cosmology — galaxies: clusters of

I. INTRODUCTION

Zwicky and Herzog (1963) describe cluster 16 in field 158 ($\alpha = 12^h18^m.2$, $\delta = 29°29'$ [1950]) as a nearby medium compact cluster with a population of 1828 galaxies and an equivalent angular diameter of 6°. It extends from 5°.0 to 12°.7 to the west of the Coma cluster. Chincarini and Rood (1972*b*) found that 35 radial velocities of galaxies in the direction of cluster 16 are divided into three classes: (i) values near 7500 km s^{-1} (which are similar to the mean redshift of the Coma cluster), (ii) values near 4000 km s^{-1}, and (iii) values in the range 200–2300 km s^{-1}.

In order to learn more about the nature of cluster 16, we have derived radial velocities for 37 more galaxies in its direction and immediate surroundings (Chincarini and Rood 1976). Fifty of the 52 galaxies brighter than $m_p = 15.1$ mag within the cluster boundaries now have known radial velocities. We regard this sample to be sufficiently complete and homogeneous as to warrant a detailed discussion.

The radial velocity field of cluster 16 is analyzed in § II. Many of the galaxies are found to be at the same redshift as the Coma cluster. The discussion of § III shows that such galaxies are probably part of the primeval cloud from which the Coma cluster formed. In this sense, the galaxies can be considered members of a larger unit: the Coma supercluster.[1] It is found that the supercluster extends to at least 14°.2 (31.5 Mpc for $H = 55$ km s^{-1} Mpc^{-1} adopted herein) from the center of the Coma cluster. Cosmological implications are briefly discussed in § IV.

* Visiting astronomer, Kitt Peak National Observatory, which is operated by the Association of Universities for Research in Astronomy, under contract with the National Science Foundation.

[1] A supercluster is defined as a large (size ~ 50 Mpc) cloud of groups and clusters of galaxies. Examples: the Local Supercluster, the Hercules complex. See Abell (1974) for further details.

II. ZWICKY-HERZOG CLUSTER 16 IN FIELD 158

Data for all 52 galaxies brighter than $m_p = 15.1$ mag in cluster 16 (homogeneous sample) and galaxies in its immediate neighborhood (inhomogeneous sample) are found in Table 1. Column (1) contains the NGC or IC identification of each galaxy. Columns (2) and (3) contain equatorial coordinates. Column (4) contains the radial distance in degrees from the center of the Coma cluster (midway between NGC 4874 and NGC 4889). Column (5) contains the apparent photographic magnitude from Zwicky and Herzog (1963). Column (6) contains the morphological type from Nilson (1973). Column (7) contains the radial velocity relative to the Local Group (de Vaucouleurs and de Vaucouleurs 1964; [BGC]). Column (8) contains the source of each radial velocity. Chincarini and Rood (1972*a*, *b*, 1976) are designated CR 1, CR 2, CR 3, respectively. Column (9) indicates membership in the Coma supercluster (Coma cl.) or the NGC 4169 group.

The radial velocity field of cluster 16 derived for our homogeneous sample is given in Figures 1 and 2, which also show magnitudes and types of galaxies, respectively. Velocities between 6200 and 9100 km s^{-1} extend over the entire field, indicating membership in the Coma supercluster. Velocities smaller than 1300 km s^{-1} also extend over the entire field, indicating membership in the Coma I cloud of the Local Supercluster (de Vaucouleurs 1976). Surrounding NGC 4169 at right ascension $12^h09^m.7$ and declination 29°27′ is a group of galaxies.

At least 11 members of the NGC 4169 group are identified. NGC 4169 has $m_p = 12.9$ mag, which is 0.8 mag brighter than the second brightest galaxy in the group. The apparent magnitudes of most members of the NGC 4169 group are indistinguishable from those of the Coma supercluster and fainter members of the Local Supercluster. The 11 group members are all spiral and S0 galaxies. NGC 4169, 4173, 4174, and

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TABLE 1

NEW RADIAL VELOCITY DATA

Star	Sp. Type	Velocity ± p.e. (km s^{-1})	N	Julian Date (2,441,000.0+)	Previous Velocity (km s^{-1})	Reference
BD +61°153.........	A0 Ib	−66.7 ± 3.6	6	606.7	...	
		−60.5 ± 2.9	5	971.7	...	
		−57.1 ± 1.8	6	972.8	...	
BD +64°76..........	B1 Ib	−56.8 ± 3.8	6	606.7	...	
		−66.1 ± 4.0	10	970.7	...	
		−61.8 ± 2.8	8	970.7	...	
		−57.2 ± 3.0	4	971.7	...	
BD +63°89	B1 Ib	−52.6 ± 2.2	6	606.7	...	
		−59.7 ± 2.9	6	971.7	...	
		−65.0 ± 3.7	6	972.8	...	
HD 4694............	B3 Ia	−50.3 ± 1.4	11	606.7	...	
		−44.7 ± 1.5	13	970.7	...	
		−46.4 ± 1.9	9	972.8	...	
HD 5776............	A0 Ib	−60.2 ± 1.7	12	606.6	...	
		−45.2 ± 1.5	10	607.7	...	
		−48.6 ± 2.7	12	970.7	...	
HD 6474............	G0 Ia	−42.0 ± 2.0	4	607.7	...	
		−42.7 ± 2.6	14	970.8	...	
		−60.2 ± 3.0	14	971.7	...	
HS Cas.............	M4 Ia–Iab	−58.3 ± 1.9	13	973.8	...	
BD +61°220.........	B7 Ib	−54.6 ± 2.8	6	607.8	...	
		−47.9 ± 2.0	7	970.8	...	
		−53.7 ± 2.0	7	971.7	...	
BD +63°180.........	A0 Ia	−72.2 ± 2.2	7	607.8	...	
		−71.5 ± 2.5	8	971.8	...	
		−67.5 ± 4.6	6	972.8	...	
		−69.7 ± 2.3	11	972.9	...	
HDE 236697.........	M2 Ib	−39.0 ± 1.5	13	973.8	−33.3	1
HD 7902............	B6 Ib	−25.5 ± 2.6	11	606.8	−28	2
		−27.5 ± 0.9	12	607.9	−31	3
		−31.7 ± 1.0	12	970.9	...	
		−34.8 ± 1.2	12	971.8	...	
		−31.1 ± 2.0	15	971.8	...	
ϕ Cas...............	F0 Ia	−30.8 ± 1.2	13	970.8	−24.4	3
		−32.6 ± 1.9	13	970.9	...	
		−23.0 ± 1.6	19	971.8	...	
BD +62°246.........	B5 Ia	−48.5 ± 1.6	10	606.9	...	
		−54.3 ± 1.5	14	607.9	...	
		−57.9 ± 1.6	14	970.9	...	
		−62.0 ± 2.4	6	971.8	...	
BD +59°274.........	M0 Ib	−60.5 ± 1.8	12	973.8	−54.0	1
HD 9973............	F5 Iab	−32.0 ± 2.4	6	606.9	...	
		−41.8 ± 2.0	13	608.0	...	
		−42.8 ± 1.8	17	970.9	...	
		−34.0 ± 1.7	17	971.9	...	
BD +62°297.........	B1 Ib	−53.9 ± 1.4	12	970.9	...	
		−52.0 ± 1.5	10	971.8	...	
		−59.4 ± 2.0	10	972.9	...	
HD 10494...........	F5 Ia	−39.7 ± 2.4	13	608.0	...	
		−37.3 ± 1.8	16	970.9	...	
		−23.1 ± 1.3	15	971.9	...	
BD +60°331.........	B8 Iab	−39.7 ± 1.2	9	607.0	...	
		−35.3 ± 2.1	12	971.0	...	
		−37.8 ± 1.3	11	971.9	...	
BD +60°333.........	B5 Iab	−38.6 ± 1.0	10	607.0	...	
		−32.2 ± 2.2	12	971.0	...	
		−38.7 ± 1.9	11	971.9	...	
BD +60°335.........	M3 Iab	−54.5 ± 1.6	13	973.9	−48.4	1
BD +60°336.........	B8 Iab	−48.9 ± 0.8	11	606.9	...	
		−36.8 ± 2.0	9	971.0	...	
		−28.9 ± 2.7	11	971.9	...	
BD +60°339.........	B6 Iab	−53.7 ± 1.3	12	606.9	−30	3
		−27.4 ± 1.6	16	971.0	...	
		−40.6 ± 1.2	14	971.9	...	
HD 10756...........	B8 Ia	−44.8 ± 1.3	9	971.0	...	
		−36.0 ± 1.7	9	971.9	...	
		−45.9 ± 1.9	11	972.9	...	
HDE 236871.........	M3 Iab	−59.5 ± 1.4	13	973.9	−55.3	1
BD +55°388.........	M2 Ib	−48.4 ± 1.8	13	973.9	−45.4	1
HD 11831...........	A2 Ia	−39.5 ± 2.4	11	972.0	...	
		−43.3 ± 1.6	10	973.0	...	
BD +59°367.........	09.5 Ib	−39.2 ± 4.8	6	972.0	...	
		−45.4 ± 1.7	6	973.0	...	

REFERENCES TO TABLE 1.—(1) Humphreys 1970; (2) Petrie and Pearce 1962; (3) Wilson 1953.

TABLE 1—*Continued*

NGC (1)	α (1950) (2)	δ (1950) (3)	r (4)	m_p (mag) (5)	Type (6)	V_0 (km s^{-1}) (7)	Source (8)	Membership (9)
4395	12 23.4	33 49	9.2	11.7	Sm	324	CR3	
4494	12 28.9	26 03	6.7	10.7	E	1305	BGC	
4525	12 31.3	30 34	6.1	13.0	Sc	1136	CR2	
4562	12 33.0	26 08	5.8	14.6	Sc	1301	CR3	
I3582	12 34.0	26 28	5.5	14.3		7113	CR2	Coma cl.
	12 36.4	32 16	6.1	14.6	S?	6972	CR3	Coma cl.
	12 36.4	32 23	6.1	14.0	S	4375	CR3	
4614	12 39.0	26 18	4.5	14.2	SB0a	4778	CR3	
4615	12 39.1	26 20	4.5	13.8	Sc	4677	CR3	
4627	12 39.5	32 51	6.0	13.3	E?	745	CR3	
4631	12 39.7	32 49	6.0	9.8	Sc	646	BGC	
4656	12 41.6	32 27	5.4	10.6	Sm	775	BGC	
4670	12 42.8	27 24	3.3	12.6	Pec	1112	CR1	
	12 44.4	26 50	3.2		E	862	CR1	
4712	12 47.1	25 44	3.4	13.5	Sc	4456	CR1, 2	
4725	12 48.0	25 46	3.2	10.2	Sb	1213	CR1	
4747	12 49.3	26 02	2.8	13.2	Ir	1216	CR1	

4175 form a tight quartet of galaxies; however, NGC 4169, 4174, and 4175 have radial velocities near 4000 km s^{-1} while NGC 4173 has a radial velocity of 1093 km s^{-1}. Evidently NGC 4173 is a member of the Local Supercluster superposed on the NGC 4169 group.

The average radial velocity of the NGC 4169 group is 3946 ± 41 km s^{-1}, and the velocity dispersion (standard deviation) is 127 ± 34 km s^{-1}. The latter value has been corrected for a mean error of 51 km s^{-1} in the radial velocity determinations of Chincarini and Rood (1972*a*, *b*, 1976) according to a 21 cm line study by Dickel and Rood (1975). A few galaxies near 4500 and 2500 km s^{-1} are located beyond the main concentration of the NGC 4169 group. Because of this eccentric location, and because their radial velocities

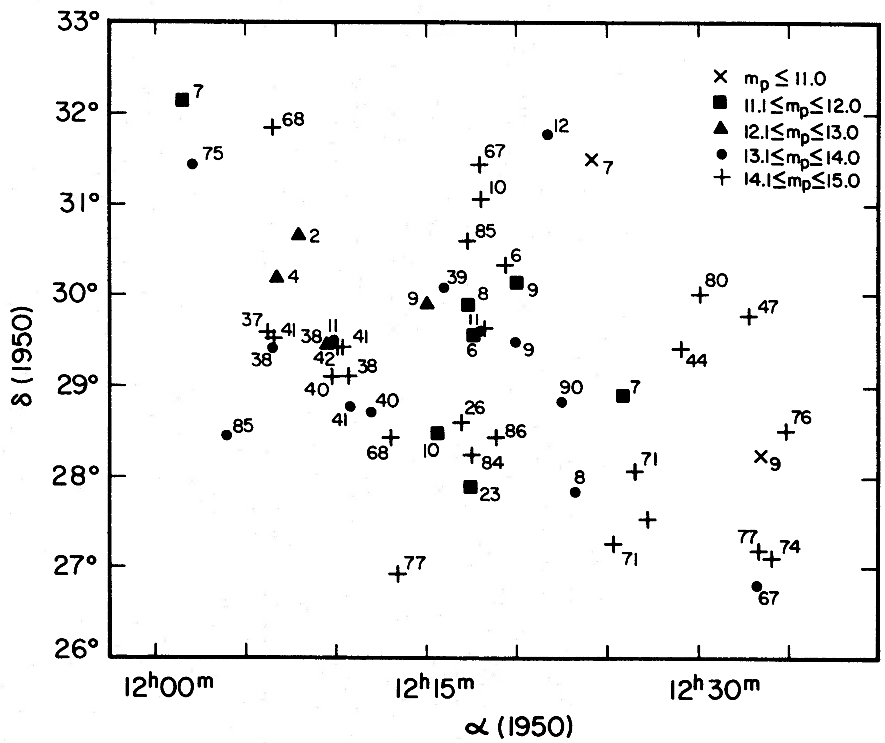

FIG. 1.—Locations, magnitudes, and radial velocities (in units of 100 km s^{-1}) of galaxies brighter than m_p = 15.1 mag in the direction of Zwicky-Herzog cluster 16 in field 158.

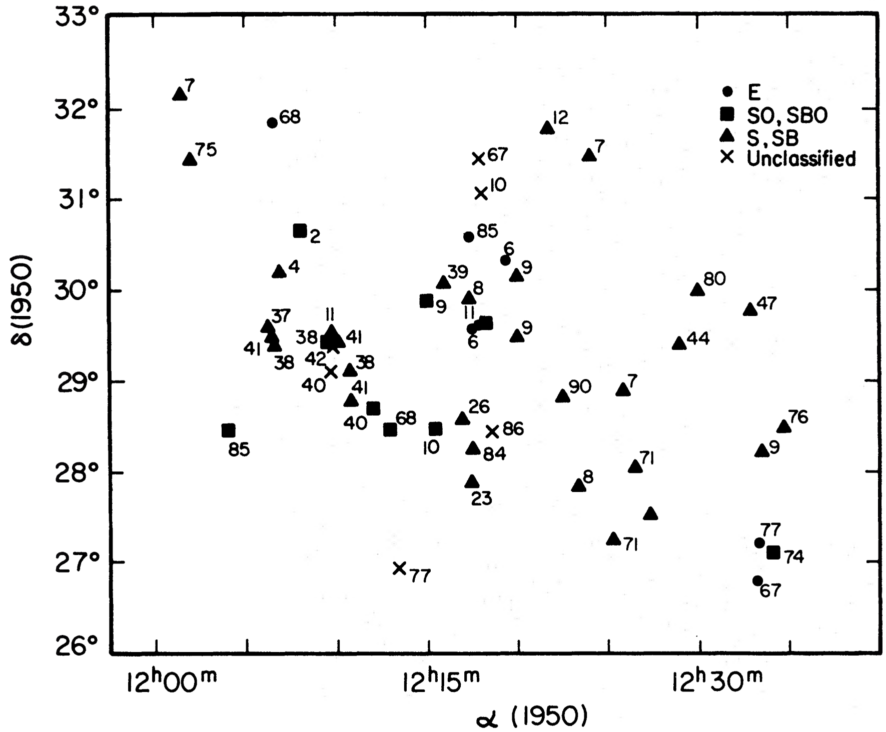

FIG. 2.—Locations, morphological types, and radial velocities (in units of 100 km s^{-1}) of galaxies brighter than m_p = 15.1 mag in the direction of Zwicky-Herzog cluster 16 in field 158.

are more than three sigmas from the group average, they probably are not members of the NGC 4169 group.

Hence, cluster 16 has been resolved into four components: (i) a portion of the Coma I cloud of the Local Supercluster, (ii) a portion of the Coma supercluster, (iii) the NGC 4169 group, and (iv) other galaxies.

III. THE COMA SUPERCLUSTER

Figure 3 is a plot of radial velocity versus distance from the center of the Coma cluster for galaxies in our homogeneous and inhomogeneous samples. Galaxies in the Coma supercluster are detected to a radial distance of 14°2 (31.5 Mpc).

The detection of supercluster members can be put on a more quantitative basis by examining the frequency distribution of the 50 known radial velocities in our homogeneous sample (Table 2). Two galaxies without radial velocity determinations prevent this sample from being complete to a limiting magnitude of m_p = 15.0 mag. The two galaxies were missed because of (i) a bookkeeping error (NGC 4475) and (ii) low-surface-brightness spectrograms (NGC 4286). Because (i) and (ii) are nearly independent of magnitude, and because the vast majority (39 of 50) of the velocities in the homogeneous sample were determined by us, we feel justified in comparing the observed frequency distribution of velocities for our homogeneous sample with theoretical distributions of samples complete to m_p = 15.0 mag. Consider a model consisting of field galaxies homogeneously distributed in space with a luminosity function approximated by (Shapiro 1971; Abell 1976)

$$f(M) = k_1 \,\mathrm{dex}\,(s_1 M)\,, \qquad M_{\min} \le M \le M\,, \qquad (1)$$

$$f(M) = k_1 \,\mathrm{dex}\,[s_1 M^* + s_2(M - M^*)]\,, \qquad M^* \le M \le M_{\max}\,; \qquad (2)$$

where $s_1 = 0.80$, $s_2 = 0.28$, $M^* = -19.8$ mag, $M_{\min} = -22.2$ mag, and $M_{\max} = \infty$. Following Rood (1975), we find that the fraction of galaxies brighter than m_p = 15.1 mag with radial velocities between 0 km s^{-1} and V is

$$\int_0^V f(V)dV = \frac{4\pi k_1}{1.842}(3.9117 \times 10^{-11} V^{1.6} - 9.0059 \times 10^{-17} V^3)\,, \quad V \le V^*\,, \qquad (3)$$

$$\int_0^V f(V)dV = \frac{4\pi k_1}{1.842}\left(3.9530 \times 10^{-5} - \frac{0.09151}{V}\right. - 5.7927 \times 10^{-19} V^3\,, \quad V \ge V^*\,; \qquad (4)$$

where V^*, the velocity corresponding to M^* and m_p = 15.0 mag, is 5016 km s^{-1}. The maximum observable radial velocity, i.e., that corresponding to $M_{\min} = -22.2$ mag and m_p = 15.0 mag, is $V_{\max}$ = 15,150 km s^{-1}.

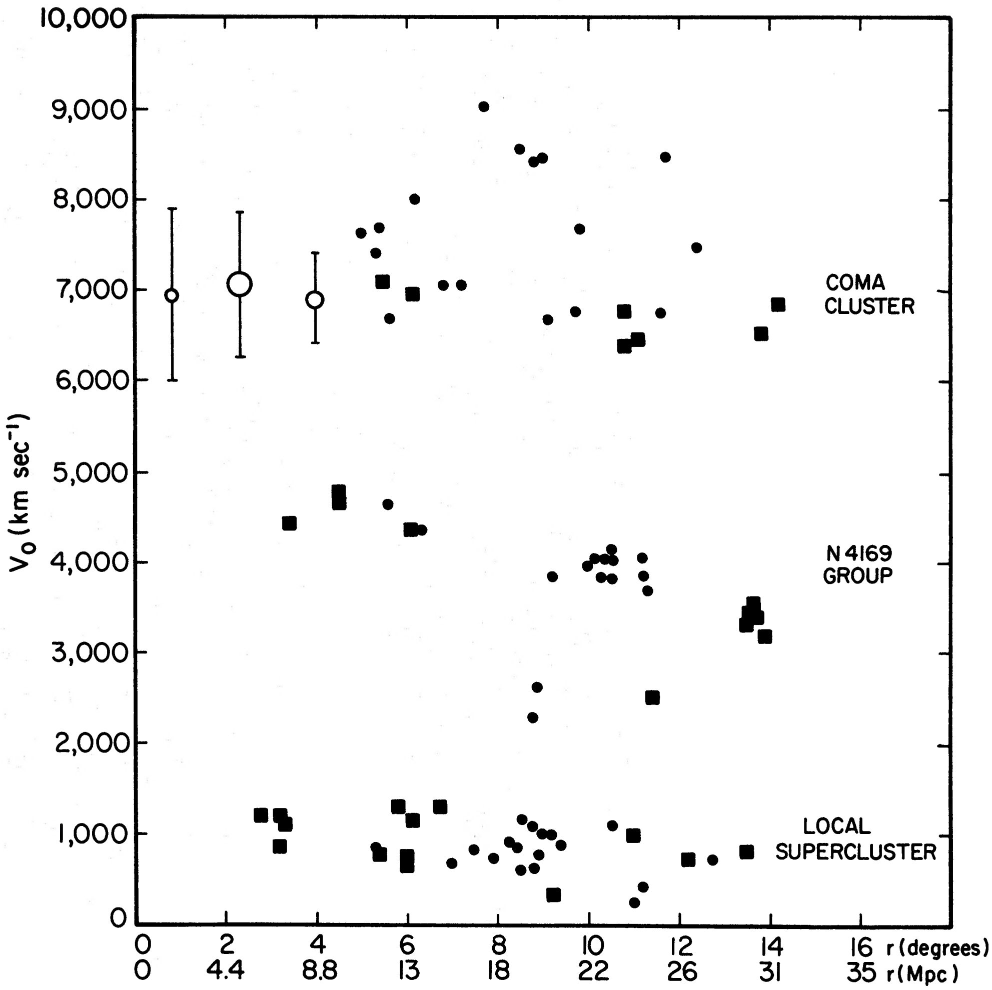

FIG. 3.—Radial velocity (relative to the Local Group) versus distance from the center of the Coma cluster, for samples of galaxies. *Closed circles*, galaxies in our homogeneous sample; *closed squares*, galaxies in our inhomogeneous sample. Open circles with error bars refer to the average velocity (radius of circle is rms uncertainty) and velocity dispersion of the Coma cluster galaxies in three annular rings calculated from radial velocity data by Gregory (1975*a*, *b*) and Tifft and Gregory (1975).

In Table 2, the observed frequency distribution of radial velocities for the 50 galaxies of our homogeneous sample is compared with a theoretical distribution for 50 galaxies homogeneously distributed in space. A χ^2 test shows that we can reject the hypothesis that the observed distribution is a random sample of the theoretical distribution with a probability greater than 99.9 percent. The velocity clumps corresponding to the Local Supercluster, the NGC 4169 group, and the Coma supercluster are evident in the observed distribution. There is no evidence for the existence of a homogeneous field of galaxies. In the following, we assume that all 17 galaxies with radial velocities between 6235 and 9083 km s^{-1} are members of the Coma supercluster.

Evidence is given in the literature that the Coma cluster contains spiral galaxies (Chincarini and Rood 1972*c*; Rood *et al.* 1972; Krupp 1972; Oemler 1974*b*; Rood 1974; Gregory 1975*a*). Of the 17 galaxies in our homogeneous sample which are members of the Coma supercluster, 14 have types given by Nilson (1973), and seven or eight (50–57%) are spirals.

The data for the Coma supercluster in our homogeneous sample will now be combined with additional homogeneous data in the literature (Gregory 1975*a*, *b*; Tifft and Gregory 1975) to derive the average surface density of galaxies brighter than $m_p = 15.0$ mag (and brighter than 15.1 mag) as a function of distance from the center of the Coma cluster for radial distances between 1°67 and 12°4. Tables 3 and 4 contain the observed number of galaxies brighter than $m_p = 15.0$ mag (and 15.1 mag) in annular rings and portions of annular rings, and corresponding average surface densities. To calculate the average surface density of galaxies as a function of distance from the center of the Coma cluster, the area of an observed portion of an annular ring is set equal to the area of the entire annular ring multiplied by the fraction (number of galaxies in relevant magnitude interval within observed portion)/(number of galaxies in relevant magnitude

TABLE 2

Frequency Distribution of Radial Velocities of Galaxies Brighter than $m_p = 15.1$ Mag within the Boundaries of Zwicky-Herzog Cluster 16 in Field 158

ΔV (km s^{-1})	$N_{obs.}$	$N_{theor.}$
000–539	2	1.4
539–1251	16	3.9
1251–1963	0	5.1
1963–2675	2	5.7
2675–3387	0	5.9
3387–4099	10	5.6
4099–4811	3	4.7
4811–5523	0	3.9
5523–6235	0	2.9
6235–6947	4	2.3
6947–7659	5	1.8
7659–8371	3	1.5
8371–9083	5	1.2
9083–9795	0	1.0
9795–10507	0	0.8
10507–11219	0	0.6
11219–11931	0	0.5
11931–12643	0	0.4
12643–13355	0	0.3
13355–14067	0	0.2
14067–14779	0	0.1
14779–15150	0	0.0

interval in the entire annular ring). The radial distribution of average surface density is illustrated in Figures 4 and 5.

We now compare the observed frequencies with theoretical frequencies derived from the formula $S \propto r^n$ for various values of n. Here S = average surface density and r = radial distance. Chi-squares fits (Rood 1975) yield $S \propto r^{-1.25 \pm 0.23 (\mathrm{m.e.})}$ for m_p brighter than 15.0 mag, and $S \propto r^{-1.30 \pm 0.21 (\mathrm{m.e.})}$ for m_p brighter than 15.1 mag. In the following, we adopt the relation $S \propto r^{-1.27 \pm 0.22 (\mathrm{m.e.})}$. A power-law radial surface density distribution provides an excellent fit, in the χ^2 sense, to the observed frequencies of galaxies brighter than $m_p = 15.1$ mag in the radial distance interval 1°67–12°4 (see Tables 3 and 4).

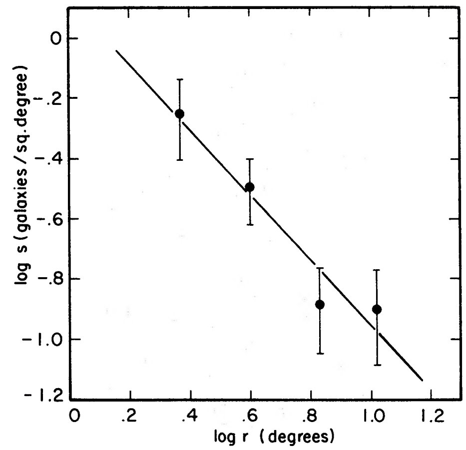

Fig. 4.—Logarithm of the average surface density of galaxies brighter than $m_p = 15.0$ mag in the Coma supercluster versus logarithm of the average radius of an annular ring centered on the Coma cluster. Error bars refer to the rms sampling uncertainty. The least-squares straight line has a slope of -1.20.

The empirical surface density formula corresponds to the relation, space density $\propto r^{-2.27 \pm 0.22 (\mathrm{m.e.})}$. The exponent is 1.2 standard deviations smaller than the isothermal value $n = -2$ found to apply outside the core of the Coma cluster but within about 1°67 of the cluster center (Zwicky 1957; Noonan 1961; Bahcall 1973; Yahil 1974).

The average radial velocity and velocity dispersion for galaxies in the Coma supercluster as a function of radial distance from the center of the Coma cluster are

TABLE 3

Radial Distribution of Galaxies Brighter than $m_p = 15.0$ Mag in the Coma Supercluster

r-Interval	Surface Density*	N_{obs}	$N_{n=0}$	$N_{n=-1/2}$	$N_{n=-1}$	$N_{n=-1.5}$	$N_{n=-2}$	$N_{n=-3}$
1°67–3°0	0.564	11	3.6	5.9	9.2	13.4	18.3	28.1
3°0–5°0	0.318	16	9.6	11.6	13.2	13.9	13.8	11.0
(5°0–8°65) × 0.4911	0.130	10	17.4	16.5	14.7	12.3	9.6	4.8
(8°65–12°4) × 0.2566	0.126	8	14.4	11.0	7.9	5.3	3.3	1.0
χ^2_{obs}			25.5	9.46	2.45	2.55	9.97	67.3
$\Pr(\chi^2 > \chi^2_{obs})$			< 0.1	2	50	50	2	< 0.1

* Galaxies per square degree.

TABLE 4

Radial Distribution of Galaxies Brighter than $m_p = 15.1$ Mag in the Coma Supercluster

r-Interval	Surface Density*	N_{obs}	$N_{n=0}$	$N_{n=-1/2}$	$N_{n=-1}$	$N_{n=-1.5}$	$N_{n=-2}$	$N_{n=-3}$
1°67–3°0	0.820	16	5.2	8.5	13.1	18.8	25.4	38.2
3°0–5°0	0.444	22.3	13.9	16.6	18.7	19.5	19.1	15.0
(5°0–8°65) × 0.4375	0.204	14	22.6	21.1	18.6	15.4	11.8	5.9
(8°65–12°4) × 0.2273	0.142	8	18.6	14.0	9.9	6.6	4.0	1.3
χ^2_{obs}			36.8	13.5	2.84	1.24	8.43	62.1
$\Pr(\chi^2 > \chi^2_{obs})$			< 0.1	0.6	40	75	4	< 0.1

* Galaxies per square degree.

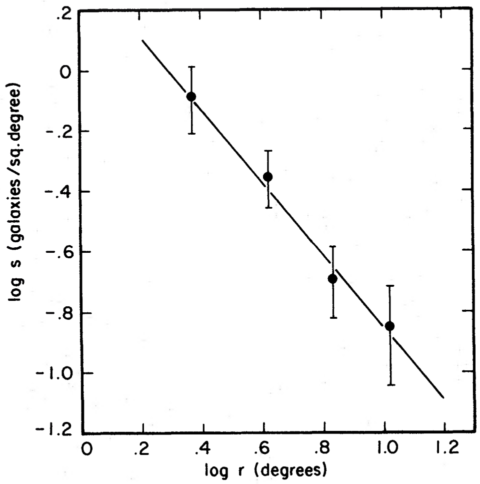

FIG. 5.—Same as Fig. 4 except that the galaxies are brighter than $m_p = 15.1$ mag and the least-squares straight line has a slope of -1.20.

found in Table 5. The average velocity does not appear to depend significantly on radial distance. The velocity dispersion also appears to be independent of radial distance except between 3° and 5°, where it is smaller than average. The velocity dispersion characteristic of the Coma supercluster is about 750 km s^{-1}.

The approximately r^{-2} density dependence estimated above follows from the assumption that the Coma supercluster is symmetrically distributed about the Coma cluster. If mass density is proportional to number density, then it follows that the luminous mass contained within r is proportional to r, so that the mass within 12° of the center of the Coma cluster would be 6 times larger than the mass within 2°. However, Tifft and Gregory (1975) present evidence that between 3° and 6° from the center of the Coma cluster there is an anisotropy in the number density distribution. A major wisp is located to the west of the Coma cluster toward the region we observed. The above mass estimate must therefore be considered an upper limit. A lower limit can be derived by counting the number of supercluster galaxies brighter than 15.0 mag in our survey and the survey by Tifft and Gregory (1975). This procedure indicates that the mass within 12° is at least 1.8 times larger than the mass within 2°. If the interpretation of our observations as given in § IV is accepted, then the velocity dispersion and therefore the virial mass of the central region, may need revision. In fact, there is a spurious contribution due to the galaxies which participate in the Hubble flow in the Coma supercluster and are seen projected on the central region. An estimate has been obtained assuming spherical symmetry (upper limit). This effect would decrease the mass by at most a factor 1.3. A more detailed analysis must await a better understanding of the structure of the cluster and the related supercluster.

IV. COSMOLOGICAL IMPLICATIONS

A galaxy moving with a velocity of $750\sqrt{3}$ km s^{-1} would take 2.4×10^{10} years to travel a distance of 31.5 Mpc. Thus, gravitational mixing of galaxies between well separated parts of the Coma region cannot be well advanced, and the large-scale properties reflect the initial conditions of the cluster formation period following the origin of the universe.

According to Oort (1970, 1975), it would then be reasonable to expect an extreme anisotropy in those parts of the Coma cluster which have not had time to mix. We may have a situation somewhat similar to the long "appendages" to the Virgo cluster. Some anisotropy has been observed by Tifft and Gregory at distances larger than 3° from the center. Lack of mixing therefore may induce a model in which the cluster became separated into two regions: a semi-relaxed region subject to the dynamical history of the cluster, which progressively fades into an outermost region (corona?) which is not relaxed and where the Hubble flow is dominant.

The center of the Coma cluster is separated from the center of the cluster A1367 by about 41 Mpc. The radial velocity of the latter cluster is about 6540 km s^{-1} (Dickens and Moss 1976; Tarenghi and Tifft 1975). Therefore, it is quite likely that the two clusters are tenuously connected and both dynamical units are "embedded" in the larger unit which we identify with the Coma supercluster. According to the above model, the galaxies in the region we observed participate in the Hubble flow within the Coma supercluster and were formed from the same primeval cloud from which the dynamical units (clusters) originated.

The situation is similar to what we observe in the Local Supercluster where the nonvirial radial velocities of galaxies reflect to a large extent the cosmological Hubble flow.

The observed radial velocity range of 6400–9000 km s^{-1} corresponds to a distance range of 47 Mpc. The velocity dispersion of about 750 km s^{-1} corresponds to a dispersion in radial distances of 14 Mpc.

TABLE 5

AVERAGE RADIAL VELOCITY AND VELOCITY DISPERSION OF GALAXIES IN ANNULAR RINGS CENTERED ON THE COMA CLUSTER

r-Interval	Number in Sample	$\langle V_0 \rangle$ (km s^{-1})	σ_{V_0} (km s^{-1})
0°–1°67	168	6946 ± 72	938 ± 51
1°67–3°0	49	7059 ± 115	805 ± 82
3°0–5°0	30	6909 ± 89	488 ± 64
5°0–8°65	17	7394 ± 162	667 ± 118
8°65–14°2	13	7211 ± 221	796 ± 162

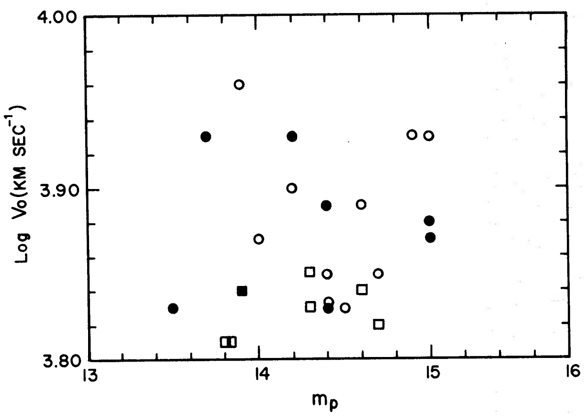

FIG. 6.—The logarithm of radial velocity versus apparent magnitude for galaxies in the Coma supercluster. *Closed circles*, elliptical and S0 galaxies in homogeneous sample; *open circles*, spiral galaxies in homogeneous sample; *closed squares*, elliptical and S0 galaxies in inhomogeneous sample; *open squares*, spiral galaxies in inhomogeneous sample.

These values compare with a detected lower limit of 31.5 Mpc for the lateral extent of the supercluster.

Our sample of galaxies in the Coma supercluster does not show a correlation between magnitude and radial velocity (Fig. 6). However, such a correlation is not necessarily expected over a magnitude range as small as 1.5 mag because of the large spread in intrinsic luminosities of the galaxies dictated by the luminosity function. To illustrate this point, we note that 1.5 mag sections of the redshift-magnitude relation for the Local Supercluster (Fig. 10 of Humason, Mayall, and Sandage 1956) show appreciable scatter and a very mild correlation, if any. It is important to extend the radial velocity measurements in the Coma supercluster to galaxies a magnitude fainter, because a correlation should be evident over a 2.5 mag interval.

Because the Coma cluster is not an isolated entity, but part of a supercluster, the cosmological formalism developed by Yahil (1974) does not apply.

The large sizes of clusters and their fading into low-density supercluster backgrounds leaves little if any space between them. On the other hand, Figure 3 clearly shows also a pronounced effect of segregation in redshifts. Such a phenomenon is observed in other regions for which we have preliminary data, as for instance in Hercules and Pegasus. This effect for the Coma region has been pointed out previously by Tifft and Gregory (1975), who conclude that the existence of field galaxies as isolated systems is in serious doubt. The so-called general field of galaxies is probably primarily the result of the low-density outskirts of clusters of galaxies and groups; in other words, it is due to those galaxies which are part of superclusters and yet did not condense into dynamically bound units (clusters or groups).

The fact that a high percentage of field galaxies are spirals is in agreement with our present findings. Furthermore, the known similarity between the luminosity function of field galaxies (Shapiro 1971) and the luminosity function of galaxies in rich clusters may be due to the fact that all galaxies are members of superclusters. In fact, most of the field galaxies analyzed by Shapiro should be part of the Local Supercluster.

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GUIDO CHINCARINI: c/o Laboratorio di Radioastronomia, Istituto di Fisica A. Righi, Via Irnerio 46, 40126 Bologna, Italy

HERBERT J. ROOD: 52 Elizabeth St., S. Bound Brook, NJ 08880