

Static Properties of Galaxies in the Cluster Abell 2199*

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(Received 25 May 1972)

For 170 galaxies in a 2-square-degree area of Abell 2199, a catalogue is presented of radial and angular coordinates, major axes, ellipticities, position angles of major axis, color, and morphological type. There is a tendency for the galaxies to lie along the major axis of the central cD galaxy. Statistical tests indicate that galaxies with small ellipticity, major axis perpendicular to that of the cD galaxy, red color, elliptical and S0 type tend to be concentrated towards the cluster center. Ellipticals and blue galaxies tend to lie along the major axis of the cD galaxy.

DETAILED observational studies of the geometrical properties of individual galaxies in rich clusters have just begun. An extensive study of the core of the Coma cluster was conducted by Rood and Baum (1967). They presented a catalogue of the 315 brightest members in a 0.32-square-degree area of the cluster, and analyzed the position angles of major axes, ellipticities, and Hubble types of individual galaxies. In the present paper, similar properties are treated for galaxies in the cluster Abell 2199.

Abell 2199 is a rich regular cluster. Clark (1968) examined the structure of the cluster from counts of galaxies to the limiting magnitude $m_{pg} \approx 18-19$. He concluded that the cluster, centered near NGC 6166, has a diameter of about 100 arc min and a counted population of 218 galaxies. Minkowski (1961) published radial velocities for 19 galaxies with an average of 9028 km/sec. For NGC 6166, Minkowski also obtained a mass of $1.4 \times 10^{13} M_{\odot}$ and a ratio of mass to luminosity of $149 M_{\odot}/L_{\odot}$ ($H=100$ km/sec-Mpc). Philip and Sanduleak (1970) listed composite color indices of 78 galaxies in Abell 2197 and 2199 obtained from low dispersion objective-prism spectra. Abell 2199 is classified as a cDp cluster in the γ supercluster by Rood and Sastry (1971).

In the present paper, we study the 170 galaxies with major axes $\gtrsim 8''$ within a region of radius 47.5 centered on NGC 6166 (Plate I, p. 525). The galaxies were selected from a Palomar Sky Survey red-sensitive print. Section I presents the measurements and a catalogue of parameters. These are analyzed in Sec. II.

I. MEASUREMENTS AND CATALOGUE

Measurements were made on 10-inch by 10-inch Palomar 48-inch Schmidt plates taken by Welch and one of us (G.N.S.) in May 1970. On a plate taken with a standard *V* filter exposed for 20 min with excellent guiding and seeing, *X*, *Y* positions of the two ends of the major and minor axes and galaxy center were measured

* Based in part on material gathered by one of us (G.N.S.) and Dr. G. A. Welch as guest investigators at the Hale Observatories.

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with the digitized two-screw Mann measuring engine at Van Vleck Observatory. The measurements, to the limiting detectable isophote, were done twice independently. In each measurement, two settings were taken for each of the five positions. Hence, each parameter is based on an average of four individual settings per position. A computer program for the IBM 1130 converted these measurements into right ascension and declination, polar coordinates (*R*, θ ; origin of *R* at NGC 6166, θ increases from north to east), angular major axis (*A*), ellipticity (ϵ), and position angle or major axis (PA). Hubble morphological types (*T*) were estimated on a III-aJ plate with a Wratten 2C filter exposed for 82 min. Approximate colors (*C*) were estimated from four-color 48-inch Schmidt plates by a method devised by Sastry (1972).

Twenty-three of the 170 galaxies are listed in the catalogue of galaxies and clusters of galaxies by Zwicky and Herzog (1966). The measured right ascensions and declinations agree with the catalogue values to within ± 0.1 min and ± 2 arc min respectively. Eighteen of the 170 galaxies are listed in the morphological catalogue by Vorontsov-Velyaminov (1962). The measured positions agree with the catalogue values to within ± 0.2 min and ± 3 arc min. The measured major axes are systematically smaller than the catalogued *D* values by 6%–10%. The mean difference between two independent determinations is 0.1 for ellipticity and 2° for position angle.

The parameters for the galaxies are listed in Table I. Column 1 gives the designation of the galaxy. Columns 2 and 3 give the rectangular coordinates *X* and *Y* centered on NGC 6166. Columns 4 and 5 give the right ascension and declination (epoch 1950). Columns 6, 7, and 8 give the angular major axis in seconds of arc (*A*), ellipticity (ϵ) corrected for the Holmberg effect (Holmberg 1946), and position angle of the major axis (PA). Columns 9 and 10 are the polar coordinates *R* and θ . Columns 11 and 12 are the color class *C* (VB = very blue, B = blue, Y = yellow, R = red, and VR = very red), and the Hubble morphological type (*T*).

TABLE I. Catalogue for 170 galaxies in Abell 2199 cluster.

No.	X	Y	R.A.	Dec.	A	ϵ	PA	R	θ	C	T
2	-37.6	1.3	16 23.0	39 41.1	26	0.3	143	42.2	2 7.1	VB	S
1	-40.6	12.2	16 23.1	39 53.1	51	0.5	36	47.5	286.7	VB	SB
3	-36.0	11.4	16 23.3	39 52.6	41	0.9	42	42.3	287.6	VR	S
4	-36.5	-13.9	16 23.3	39 24.0	15	0.8	31	43.8	249.1	B	SO
5	-32.8	0.8	16 23.7	39 40.6	22	0.3	44	36.8	271.5	R	SB
6	-32.4	18.1	16 23.7	40 -0.1	55	0.6	98	41.6	299.2	VR	S
7	-30.4	14.9	16 23.9	39 56.4	22	0.7	22	38.0	296.2	VR	SO
8	-30.4	3.7	16 23.9	39 43.8	30	0.5	32	34.4	276.9	R	E
9	-28.7	-3.8	16 24.1	39 35.2	10	0.3	90	32.5	262.3	Y	E
10	-29.4	20.0	16 24.2	40 1.9	23	0.6	166	39.9	304.3	VR	SO
11	-29.0	-5.1	16 24.2	39 33.6	19	0.6	166	33.1	259.9	Y	SO
12	-26.1	8.5	16 24.2	39 49.1	18	0.5	83	30.8	288.1	R	SB
13	-26.0	4.0	16 24.3	39 44.3	18	0.5	122	29.5	278.9	R	SO
14	-25.9	-16.5	16 24.3	39 21.2	17	0.4	81	34.5	237.5	R	SO
15	-26.0	-21.3	16 24.3	39 15.7	10	0.3	174	37.7	230.7	B	SO
21	-23.2	-10.4	16 24.4	39 27.9	12	0.0	0	28.5	245.8	VR	SO
16	-24.7	6.8	16 24.5	39 47.4	21	0.6	88	28.7	285.6	VR	SO
18	-24.5	-24.1	16 24.5	39 12.5	10	0.2	40	38.6	225.5	VR	SO
19	-24.5	-7.4	16 24.5	39 31.2	25	0.7	170	28.8	253.1	R	SO
22	-22.9	-12.2	16 24.5	39 25.8	13	0.1	153	29.1	241.9	R	E
20	-25.2	23.9	16 24.6	40 6.3	13	0.0	0	39.0	313.6	B	PEC
23	-22.9	-25.3	16 24.6	39 11.4	13	0.3	32	38.3	222.1	R	E
24	-21.9	-5.4	16 24.7	39 33.6	11	0.0	0	25.4	256.2	R	SB.
25	-21.9	-9.0	16 24.7	39 29.6	14	0.5	149	26.6	247.6	B	S
26	-21.8	-19.3	16 24.7	39 18.1	15	0.0	0	32.6	228.5	R	SO
27	-21.2	-22.4	16 24.8	39 14.5	32	0.7	42	34.6	223.4	Y	S
28	-21.1	18.8	16 24.8	40 0.6	10	0.0	0	31.7	311.8	VR	E
29	-20.6	16.8	16 24.9	39 58.5	24	0.6	82	29.9	309.2	R	S
31	-18.8	34.9	16 24.9	40 18.7	18	0.4	173	44.5	331.7	B	S
30	-20.7	4.7	16 25.0	39 44.8	19	0.3	171	23.9	282.8	VR	SB
32	-17.3	-26.3	16 25.0	39 10.1	26	0.4	63	35.3	213.4	Y	S
33	-18.3	16.7	16 25.0	39 58.5	33	0.7	169	27.8	312.4	B	S
34	-17.2	-9.4	16 25.2	39 29.2	15	0.3	161	22.0	241.3	VB	SB
35	-16.9	-12.5	16 25.2	39 25.6	30	0.8	166	23.6	233.4	VR	SO
37	-16.2	-6.1	16 25.3	39 32.8	14	0.5	81	19.5	249.3	R	SO
38	-16.3	-0.9	16 25.3	39 38.5	22	0.1	120	18.4	266.7	R	E
36	-14.6	-32.0	16 25.4	39 3.8	15	0.5	152	39.5	204.6	VB	SO
39	-15.3	2.1	16 25.4	39 42.0	20	0.7	127	17.4	278.1	VR	SO
41	-13.5	-20.7	16 25.4	39 16.3	16	0.3	76	27.7	213.1	R	S
40	-16.3	-12.1	16 25.5	39 25.9	19	0.4	51	22.8	233.3	R	SO

II. ANALYSIS

A. Field Galaxies

We first estimate the contribution of field galaxies to our sample. From a calibration curve derived from a central zone of the Coma cluster, we estimate that the

size limit of our sample corresponds to a limiting magnitude of $P=17^m0$. Counts by Shane and Wirtanen (1967) indicate about 40 field galaxies per square degree to $P=19^m0$. If we assume a factor of 4 field galaxies per magnitude, we find that our 2-square-degree sample to $P=17^m0$ contains five field galaxies. To ob-

TABLE I (continued)

No.	X	Y	R.A.	Dec.	A	ϵ	PA	R	θ	C	T
42	-13.6	-9.8	16 25.5	39 28.8	41	0.8	14	18.9	234.3	VR	SO
43	-12.9	-24.5	16 25.5	39 12.3	37	0.3	152	31.1	207.8	B	S
44	-13.3	-16.1	16 25.5	39 21.5	23	0.7	124	23.5	219.6	R	SO
45	-12.3	-36.8	16 25.6	38 58.5	26	0.4	11	43.5	198.5	VR	SB
46	-10.9	-35.1	16 25.8	39 0.3	15	0.6	163	41.3	197.3	B	S
47	-11.3	-24.0	16 25.8	39 12.8	12	0.3	50	29.8	205.2	Y	PEC
48	-10.9	-22.0	16 25.8	39 14.8	12	0.3	34	27.5	206.4	VR	E
49	-10.8	-14.8	16 25.8	39 22.9	36	0.6	153	20.6	216.2	B	SB
50	-12.4	1.9	16 25.9	39 41.6	19	0.0	0	14.1	279.1	VR	E
51	-8.6	-31.5	16 25.9	39 4.2	18	0.3	145	36.6	195.3	VB	I
52	-9.4	-9.9	16 25.9	39 28.6	41	0.2	89	15.4	223.5	VR	E
53	-9.4	-9.2	16 25.9	39 29.4	17	0.5	178	14.8	225.6	Y	SO
54	-9.4	-9.8	16 25.9	39 28.7	16	0.5	44	15.3	223.6	VR	S.
55	-9.6	36.9	16 25.9	40 21.0	13	0.0	0	42.8	345.4	Y	PEC
57	-9.4	32.1	16 25.9	40 15.6	15	0.6	27	37.5	343.6	Y	S
58	-9.4	36.0	16 25.9	40 19.9	15	0.4	27	41.8	345.3	R	SO
56	-9.2	-0.5	16 26.0	39 39.0	15	0.4	71	10.4	266.4	VR	E
59	-9.3	35.7	16 26.0	40 19.6	36	0.6	45	41.4	345.4	VR	SB
60	-10.4	33.2	16 26.0	40 16.7	18	0.4	31	39.1	342.6	B	S
61	-6.9	-14.6	16 26.0	39 23.1	22	0.2	153	18.2	205.3	VR	E
63	-7.1	9.3	16 26.1	39 50.1	8	0.0	0	13.2	322.8	R	S
64	-7.1	-15.0	16 26.1	39 22.9	11	0.0	0	18.6	205.4	R	E
62	-6.7	-0.0	16 26.2	39 39.7	26	0.3	142	7.5	269.3	VR	SO
65	-6.7	-13.6	16 26.2	39 24.4	22	0.3	142	17.1	206.1	R	SB
66	-7.1	-16.1	16 26.2	39 21.6	15	0.3	122	19.8	203.8	R	SO
67	-6.7	2.8	16 26.2	39 42.8	14	0.0	0	8.2	292.8	VR	SB0
68	-5.8	-27.9	16 26.3	39 8.2	12	0.3	26	32.0	191.9	R	SO
69	-5.3	-1.3	16 26.3	39 38.1	12	0.3	43	6.2	255.8	VR	E
71	-3.0	-18.5	16 26.4	39 18.7	18	0.8	76	21.1	189.3	B	S
70	-5.5	15.3	16 26.5	39 56.5	43	0.2	6	18.2	340.2	R	SB
72	-3.1	-40.6	16 26.5	38 54.2	17	0.0	0	45.7	184.4	VR	E
73	-3.7	-0.9	16 26.5	39 38.6	14	0.5	131	4.4	256.2	VR	S.
74	-3.2	40.2	16 26.5	40 24.7	31	0.0	0	45.2	355.4	VR	SB
75	-3.1	29.8	16 26.5	40 13.1	18	0.2	11	33.6	354.0	VR	SO
76	-2.4	0.7	16 26.6	39 40.5	20	0.2	81	2.9	287.7	VR	E
78	-2.9	21.9	16 26.6	40 4.1	16	0.4	50	24.8	352.4	VR	E
77	-2.4	2.8	16 26.6	39 42.8	14	0.5	167	4.2	319.4	R	SO
79	-1.4	-23.9	16 26.7	39 12.7	12	0.5	35	26.8	183.5	Y	SO
80	-3.2	10.9	16 26.7	39 51.8	23	0.3	91	12.8	343.3	VR	SO
81	0.4	-23.9	16 26.7	39 12.8	27	0.5	56	26.8	179.0	VB	S
84	-0.7	8.8	16 26.7	39 49.5	42	0.7	143	9.9	355.1	VR	SO
91	1.3	-7.8	16 26.7	39 30.8	13	0.5	85	8.9	169.9	VR	SO.
83	-0.9	-2.2	16 26.7	39 37.1	29	0.6	121	2.8	202.0	R	SO
82	-0.2	-8.1	16 26.8	39 30.6	17	0.5	157	9.2	181.7	VR	SO
85	-0.4	-0.5	16 26.8	39 39.0	15	0.5	72	0.9	220.2	R	SO
86	-0.2	-1.2	16 26.8	39 38.3	14	0.4	162	1.4	192.9	VR	E
87	-0.2	-5.7	16 26.8	39 33.2	13	0.8	45	6.5	182.1	Y	E+E

TABLE I (continued)

No.	X	Y	R.A.	Dec.	A	ϵ	PA	R	θ	C	T
88	-0.1	7.9	16 26.8	39 48.5	27	0.5	145	8.9	359.1	R	S
89	0.0	0.0	16 26.9	39 39.7	56	0.3	42	(ORIGIN)		R	D
92	1.1	29.5	16 26.9	40 12.8	32	0.5	152	33.1	2.3	B	SB
90	-0.9	-0.9	16 27.0	39 38.4	16	0.3	156	1.5	224.5	VR	SB
93	1.4	29.9	16 27.0	40 13.3	24	0.3	101	33.6	2.7	Y	SB
94	1.3	-6.6	16 27.0	39 32.3	14	0.0	0	7.6	168.5	R	SO
95	1.5	-5.2	16 27.0	39 33.8	38	0.8	164	6.1	163.5	VR	SO
96	1.1	-4.4	16 27.0	39 34.6	35	0.0	0	5.1	166.1	R	SB
97	1.0	-3.6	16 27.0	39 35.5	15	0.5	137	4.3	163.8	R	SO
98	0.9	-1.8	16 27.0	39 37.5	17	0.0	0	2.4	152.1	VR	E
99	1.9	3.5	16 27.0	39 43.5	16	0.5	82	4.5	28.6	R	SO
101	3.0	-27.4	16 27.0	39 8.8	27	0.3	168	30.9	173.6	R	SO
102	2.8	14.0	16 27.1	39 55.5	27	0.0	0	16.1	11.5	B	S
103	2.6	10.2	16 27.1	39 51.0	15	0.3	161	11.8	14.7	VR	SO
105	2.6	-0.0	16 27.1	39 39.6	18	0.2	9	2.9	91.3	VB	PEC
108	2.7	-12.4	16 27.1	39 25.6	48	0.8	112	14.3	167.4	Y	S
100	0.9	-19.6	16 27.2	39 17.5	13	0.0	0	22.1	177.2	VR	SO
104	3.5	7.8	16 27.2	39 48.5	12	0.0	0	9.7	24.4	Y	SBO
106	3.4	4.7	16 27.2	39 45.0	18	0.5	153	6.6	36.0	R	SO
107	3.8	13.2	16 27.2	39 54.5	10	0.3	137	15.5	16.0	R	E
109	3.6	7.0	16 27.2	39 47.5	16	0.4	108	8.9	27.4	VR	E
110	2.6	-14.1	16 27.2	39 23.6	15	0.1	128	16.2	169.4	R	SO
111	4.9	-20.8	16 27.2	39 16.2	29	0.6	170	24.0	166.7	R	SO
112	5.2	-4.2	16 27.3	39 35.1	17	0.4	26	7.5	128.7	VR	SO
113	5.4	13.1	16 27.4	39 54.5	10	0.0	0	16.0	22.5	VR	E
114	6.1	5.7	16 27.4	39 46.1	31	0.5	131	9.4	46.8	R	SB
115	6.4	-8.7	16 27.5	39 29.9	38	0.8	15	12.1	143.7	VR	SO
116	6.9	-7.0	16 27.5	39 31.8	27	0.4	162	11.1	135.5	R	SBO
117	7.4	3.3	16 27.6	39 43.4	6	0.0	0	9.2	65.6	VB	PEC
118	7.3	37.8	16 27.6	40 21.9	40	0.7	43	43.2	11.0	VB	SB
119	7.1	36.8	16 27.6	40 20.7	25	0.3	60	42.0	11.0	B	S
126	7.5	-40.1	16 27.6	38 54.8	11	0.1	42	45.7	169.4	R	SB
120	6.4	14.9	16 27.7	39 56.1	28	0.5	39	18.2	23.2	R	SO
131	11.6	11.1	16 27.7	39 52.0	28	0.6	39	18.0	46.3	VR	SO
122	10.7	21.6	16 27.8	40 4.0	11	0.3	128	27.1	26.4	B	PEC
123	10.1	17.8	16 27.8	40 0.3	16	0.5	156	23.0	29.5	VR	E
124	11.4	35.8	16 27.9	40 19.7	32	0.8	74	42.2	17.6	Y	S.
125	11.9	36.7	16 28.0	40 20.8	15	0.5	139	43.3	18.0	VR	SBO
128	11.6	24.6	16 28.0	40 7.1	18	0.5	33	30.6	25.4	Y	S
132	12.5	7.3	16 28.0	39 48.1	32	0.2	34	16.4	59.6	R	SO
133	11.8	-18.3	16 28.0	39 19.2	12	0.0	0	24.5	147.2	VR	SO
127	13.1	35.4	16 28.1	40 19.3	28	0.5	40	42.3	20.3	VR	SBO
130	10.6	14.3	16 28.1	39 55.5	21	0.1	16	20.0	36.5	R	SB
134	12.8	10.6	16 28.1	39 51.6	62	0.1	15	18.8	50.3	R	E
129	12.4	23.1	16 28.1	40 5.5	21	0.6	34	29.4	28.2	R	SO

tain an independent estimate of the contribution of field galaxies, counts were made in three zones of 2 square degrees in fields adjacent to Abell 2199. We

found an average of 15 field galaxies. Hence, since there are only about 5 to 15 field galaxies in our sample, we neglect them in our analysis.

TABLE I (continued)

No.	X	Y	R.A.	Dec.	A	ϵ	PA	R	θ	C	T
137	12.6	-37.0	16 28.1	38 58.1	13	0.5	151	43.9	161.1	VR	SO
135	13.9	20.3	16 28.2	40 2.4	22	0.1	44	27.7	34.5	VR	F
136	13.8	-1.9	16 28.2	39 37.5	24	0.3	80	15.7	97.8	R	SO
138	15.4	20.5	16 28.4	40 2.6	16	0.6	84	28.8	36.9	VR	SB.
139	15.4	-13.9	16 28.4	39 23.9	17	0.5	110	23.4	132.1	R	SBO
141	17.4	-26.8	16 28.4	39 9.5	10	0.0	0	35.8	147.0	VR	S
140	14.7	-37.0	16 28.5	38 58.0	17	0.5	10	44.6	158.3	B	PEC
143	17.6	16.7	16 28.5	39 58.6	42	0.6	55	27.4	46.2	Y	SO
142	18.5	-14.2	16 28.6	39 23.8	17	0.5	92	26.2	127.5	VR	SO
144	17.9	12.5	16 28.6	39 53.8	13	0.0	0	24.5	54.9	B	PEC
145	18.8	14.1	16 28.7	39 55.5	15	0.0	0	26.4	53.2	R	S
146	19.0	3.2	16 28.7	39 43.3	43	0.6	156	21.6	80.4	VR	S
147	19.3	-9.6	16 28.7	39 28.9	28	0.5	99	24.2	116.4	R	SO
151	21.8	-18.7	16 28.7	39 18.5	34	0.5	56	32.3	130.7	VR	E
148	19.9	31.9	16 28.8	40 15.2	25	0.5	101	42.2	32.0	VR	SO
149	19.9	14.4	16 28.8	39 55.8	32	0.5	133	27.6	54.0	B	S
153	21.9	3.0	16 28.9	39 43.1	39	0.8	142	24.8	82.0	R	SO
150	19.5	34.2	16 29.0	40 17.8	26	0.5	26	44.2	29.7	R	E
152	22.3	-19.6	16 29.0	39 17.8	53	0.7	112	33.3	131.4	VR	SO
154	22.8	21.7	16 29.0	40 4.1	10	0.3	49	35.4	46.4	R	E
155	23.4	22.5	16 29.1	40 4.8	40	0.8	53	36.4	46.1	R	S.
156	23.5	15.1	16 29.1	39 56.6	34	0.6	97	31.4	57.3	R	SO
161	25.8	15.6	16 29.2	39 57.0	42	0.2	153	33.8	58.8	VR	SB
157	24.9	-19.3	16 29.3	39 18.0	16	0.0	0	35.4	127.7	VB	S
158	24.6	-0.0	16 29.3	39 39.5	56	0.8	20	27.7	90.1	VR	SO
159	24.9	12.3	16 29.3	39 53.4	42	0.0	0	31.1	63.7	Y	SO
160	24.1	-6.4	16 29.4	39 32.3	67	0.8	61	27.9	104.9	VR	S
162	27.5	-23.2	16 29.5	39 13.7	24	0.0	0	40.4	130.2	VR	E
163	27.9	-22.0	16 29.5	39 15.1	39	0.8	13	39.8	128.2	R	SO
165	27.6	11.9	16 29.5	39 53.0	19	0.6	18	33.7	66.6	R	E
166	27.4	16.5	16 29.5	39 58.2	18	0.5	31	35.9	58.9	Y	S
167	27.1	30.4	16 29.5	40 13.7	22	0.0	0	45.7	41.8	R	E
168	27.7	9.6	16 29.5	39 50.4	28	0.4	152	32.9	70.8	R	E
169	27.8	12.1	16 29.6	39 53.2	21	0.6	101	34.0	66.4	R	SBO
171	30.7	23.7	16 29.7	40 6.1	18	0.5	13	43.5	52.4	R	SB
170	28.9	18.5	16 29.9	39 60.1	31	0.4	47	38.5	57.4	R	SO
172	33.7	-24.9	16 30.1	39 11.9	25	0.6	32	47.0	126.4	R	SO
173	38.9	-2.7	16 30.6	39 36.5	24	0.3	30	43.7	94.0	Y	S

B. Radial and Angular Distributions

For our study, each parameter was divided into three or four classes given in Table II. PA₁ refers to galaxies with major axes oriented nearly along the major axis of the cD galaxy, PA₃ to orientations nearly perpendicular to the cD major axis, θ_2 and θ_4 perpendicular to the cD major axis. To examine the radial and angular distributions of each parameter class, contingency tables for each parameter vs R_1 , R_2 , R_3

and θ_1 , θ_2 , θ_3 , θ_4 were constructed, and chi-square tests for independence were performed. For example, to determine whether galaxies of different sizes have different radial distributions, the following table giving the frequency distribution of A_i , R_j ($i=1, 2, 3$, $j=1, 2, 3$) was set up:

	R_1	R_2	R_3
A_1	17	19	17
A_2	23	19	18
A_3	20	18	19.

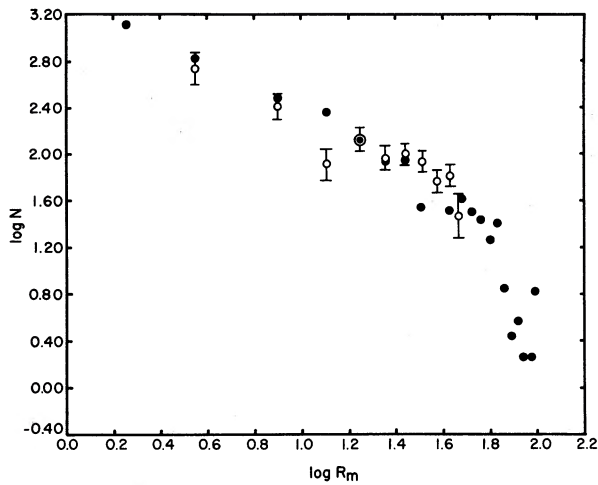
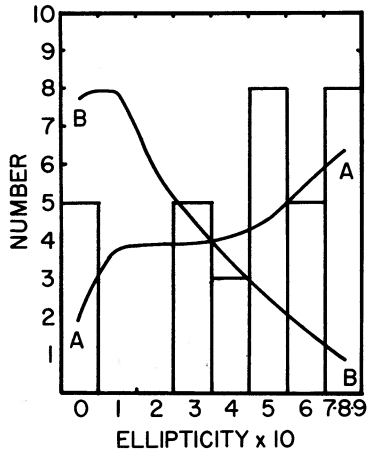


FIG. 1. Number of galaxies in rings per square degree vs rms distance from the cluster center. Open circles represent counts for Abell 2199. Closed circles represent counts (corrected for field galaxies) by Zwicky (1957) from an 18-inch Palomar Schmidt plate. The counts for the Coma cluster have been normalized to agree with the Abell 2199 counts at $\log R_m = 1.25$.

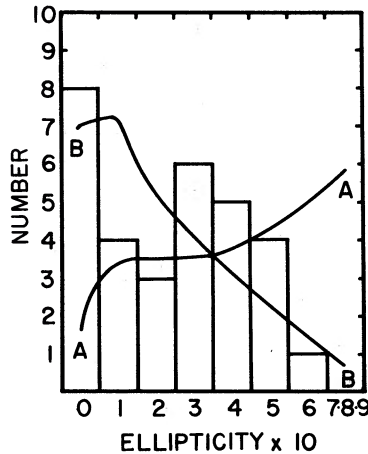
TABLE II. Parameter classes.

R_1 : 0' - 19'0	θ_1 : 0'0- 89'9
R_2 : 19.1- 33.0	θ_2 : 90.0-179.9
R_3 : 33.1- 47.5	θ_3 :180.0-269.9
	θ_4 :270.0-359.9
A_1 : 0'' - 15''	e_1 : 0.0- 0.2
A_2 : 16 - 25	e_2 : 0.3- 0.4
A_3 : 26 - 67	e_3 : 0.5- 0.9
PA_1 : 30° - 59°	B':VB, B, Y
PA_2 : 60 -104	R:R
165 - 29	VR:VR
PA_3 :105 -164	
E:E	
S0':S0, SB0, cD	
S':S, SB, I, Peculiar	

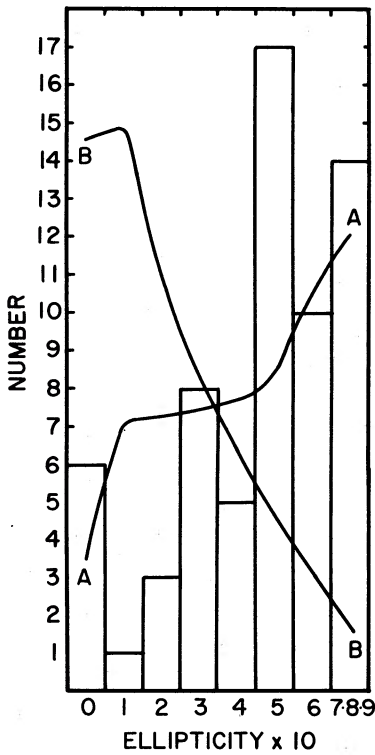
A chi-square test shows that the radial distributions are different on only the 2.5% confidence level. We conclude that there is no statistically significant dependence of radial distribution on size.



(a)



(c)



(b)

FIG. 2. Frequency distributions of observed ellipticities for (a) spiral, (b) S0, and (c) elliptical galaxies. Curve A is a theoretical distribution where all galaxies have the same intrinsic ellipticity 0.7. Curve B is a theoretical distribution where all intrinsic ellipticities occur with the same probability.

TABLE III. Significantly different radial and angular distributions ($\geq 90\%$ confidence level).

Confidence Level		R_1	R_2	R_3	
95%	ϵ_1	20	12	12	Galaxies with small ellipticities show a greater concentration to the cluster center than galaxies with large ellipticities.
	ϵ_3	9	17	18	
99.5%	R_1	7	11	19	Galaxies near the cluster center tend to have major axes perpendicular to that of the cD galaxy, outer galaxies have major axes parallel to that of the cD.
	PA_3	22	15	9	
99.5%	R_1	7	16	25	Blue galaxies are less concentrated towards the cluster center than red galaxies.
	VR	26	17	17	
98%	R_1	15	9	8	Elliptical galaxies show greater concentration to the cluster center than spirals.
	S'	13	22	31	
98%	R_1	28	25	19	$S0'$ galaxies show greater concentration to the cluster center than spirals.
	S'	13	22	31	
99.5%	θ_1	10	26	9	Small galaxies tend to lie in third quadrant, large galaxies in first quadrant.
	A_3	21	10	14	
98%	θ_1, θ_3	34	14		Blue galaxies tend to lie along major axis of cD galaxy.
	VR	28	32		
95%	θ_1, θ_3	24	8		Elliptical galaxies tend to lie along major axis of cD galaxy.
	SO'	39	33		
92%	θ_1, θ_3	24	8		Elliptical galaxies tend to lie along major axis of cD galaxy.
	S'	37	29		

Table III gives results for the parameters which have different radial and angular distributions on $\geq 90\%$ confidence level. It is seen that galaxies with small ellipticity, major axis perpendicular to that of the cD galaxy, red color, elliptical and $S0$ type are more concentrated towards the cluster center than are galaxies with large ellipticity, major axis parallel to that of the cD galaxy, blue color, and spiral type. Ellipticals and blue galaxies tend to lie along the major axis of

the cD galaxy. Small galaxies tend to lie in the 270° – 360° quadrant, large galaxies in the 0° – 90° quadrant.

C. Correlations among Parameters

Ten contingency tables were examined in a search for correlations among the parameters A , PA , ϵ , C , T . Significant correlations are indicated in Table IV. As expected, elliptical and $S0/SB0$ galaxies tend to be red, spirals tend to be blue. All peculiar galaxies are blue.

TABLE IV. Significant correlations.

Confidence Level		E	$S0'$	S'	
>99.5%	B'	2	10	36	Elliptical and $S0$ galaxies tend to be red. Spirals tend to be blue. All of the peculiar galaxies are blue.
	R	12	34	16	
	VR	18	28	14	
	E	0	0	0	
	VB	0	2	0	S
	B	0	2	0	3
	Y	2	5	1	10
	R	12	31	3	8
99%	VR	18	25	3	6
	E	0	0	0	10
	ϵ_1	15	12	17	6
	ϵ_2	15	35	32	10
	ϵ_3	2	25	17	6
	A_1	10	11	16	7
	PA_1	10	30	19	7
	PA_2	10	13	18	7
90%	ϵ_1	22	27	4	SB
	A_1	13	33	14	3
	A_2	9	22	26	1
	A_3	9	22	26	0
	ϵ_1	22	27	4	I
	A_1	13	33	14	1
	A_2	9	22	26	0
	A_3	9	22	26	0
>99.5%	ϵ_1	22	27	4	PEC
	A_1	13	33	14	2
	A_2	9	22	26	4
	A_3	9	22	26	2
	ϵ_1	22	27	4	0
	A_1	13	33	14	0
	A_2	9	22	26	0
	A_3	9	22	26	0

Ellipticals tend to be less flat than $S0/SB0$ and spiral galaxies.

Medium-sized galaxies have position angles neither aligned nor perpendicular to the major axis of the cD galaxy.

The larger galaxies tend to have the larger ellipticities.

TABLE V. Frequency distributions.

θ	Number	A	Number	PA	Number
0°–30°	20	0'–4''	0	0°–20°	12
30–60	21	5–9	2	20–40	22
60–90	7	10–14	36	40–60	22
90–120	6	15–19	50	60–80	8
120–150	13	20–24	21	80–100	17
150–180	15	25–29	21	100–120	7
180–210	19	30–34	13	120–140	14
210–240	18	35–39	8	140–160	22
240–270	15	40–44	11	160–180	18
270–300	15	45–49	1		
300–330	7	50–54	2		
330–360	14	55–59	3		
		60–64	1		
		65–69	1		
	C	Number	T	Number	
	VB	11	E	32	
	B	18	S0	65	
	Y	19	SB0	7	
	R	62	S	34	
	VR	60	SB	23	
			I	1	
			PEC	8	

Ellipticals tend to be less flat than S0/SB0 and spiral galaxies. More surprising, however, is the tendency for the larger galaxies to have larger ellipticities. Also, medium-sized galaxies tend to have position angles neither aligned along nor perpendicular to the major axis of the cD galaxy.

D. Frequency Distributions

The radial distribution of the Abell 2199 cluster members is compared with that of the Coma cluster in Fig. 1. The similarity between these two distributions is striking.

The frequency distributions of ellipticities for S, S0, E galaxies are shown in Fig. 2. Also included are the theoretical frequency distributions for two models: (a) All of the intrinsic ellipticities are 0.7; (b) intrinsic ellipticities from 0.0 through 0.7 are equally probable.

The theoretical distributions are taken from Hubble (1926). Whereas the S and S0 galaxies are better represented by model (a), the ellipticals are fit better by model (b), in agreement with the conclusions by Rood and Baum (1967) for the galaxies in the Coma cluster, and Sandage, Freeman, and Stokes (1970) for the galaxies in the de Vaucouleurs Reference Catalogue (1964).

The frequency distribution of θ is nonrandom on the 96% confidence level, which indicates a tendency for galaxies to lie along the major axis of the cD galaxy (PA=42°). The frequency distribution of PA's is also nonrandom on the 97.5% confidence level. The PA's tend to lie approximately along the major axis of the cD galaxy, or perpendicular to it.

ACKNOWLEDGEMENTS

This work is supported in part by the National Science Foundation Research Grant GP-19020.

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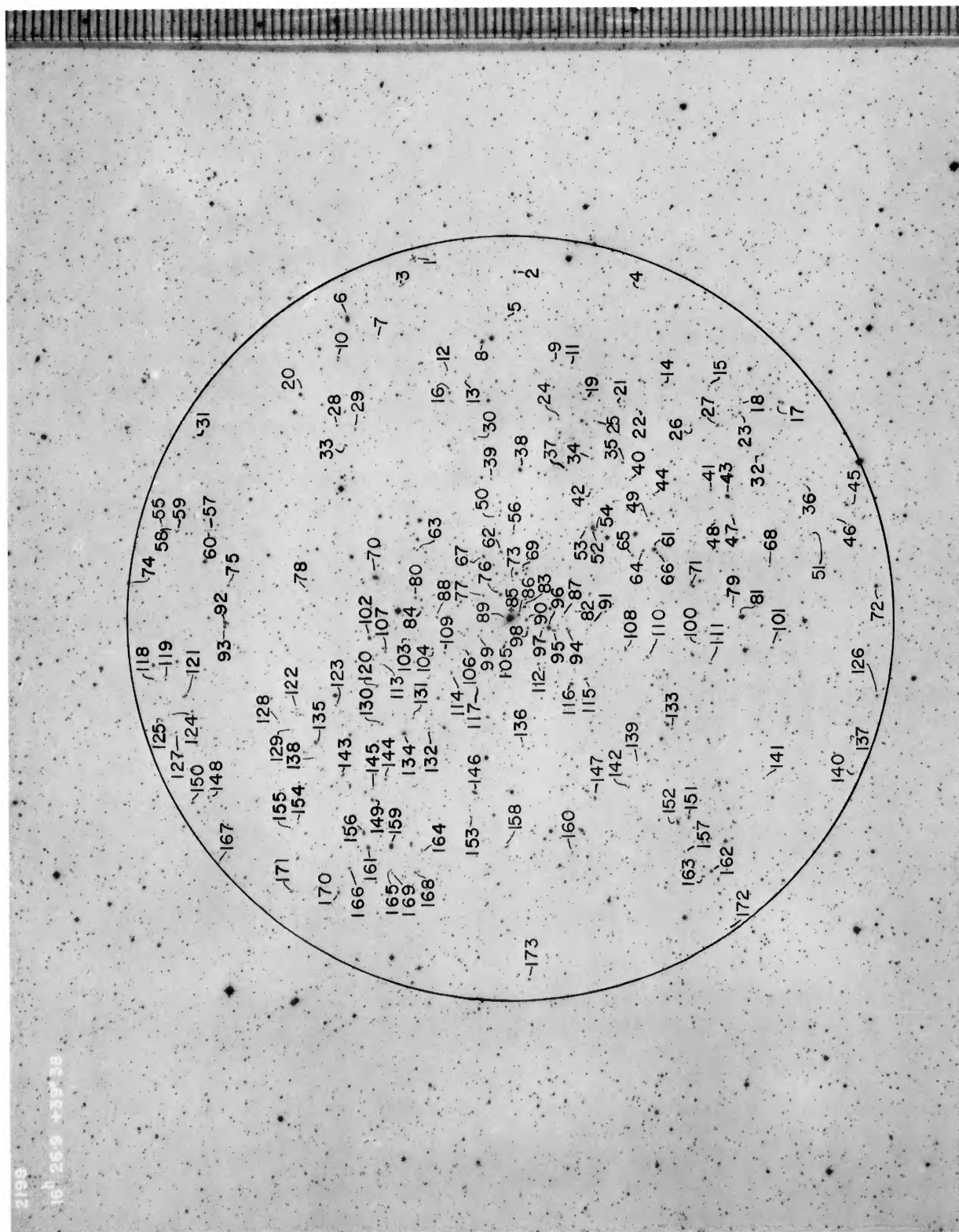


PLATE I (Rood and Sastry, p. 451). Identification chart for 170 galaxies in Abell 2199. Numbers 17, 121, and 164 are stars.

