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THE NGC 507 CLUSTER OF GALAXIES

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ABSTRACT

Redshifts and accurate positions for galaxies in the core of the NGC 507 group are presented. The group is shown to be closely similar to other groups of galaxies located nearby, including the Perseus cluster. A conventional virial analysis shows the usual excess kinetic energy. The redshift-magnitude diagram is consistent with the presence of bands.

Subject headings: galaxies, cluster of — redshifts

I. INTRODUCTION

NGC 507 and a number of neighboring galaxies define one major concentration of galaxies toward the eastern end of a nearby cluster. The more central aggregate in the cluster is the NGC 383 or Pisces group of galaxies. Zwicky and Kowal (1968) describe the cluster (0107.5 + 3212) as medium compact with a population of 625. They show the cluster extending over a NE–SW elongated region roughly 8° × 2°. NGC 507 = Arp 229 = VV 207 is a somewhat peculiar elliptical galaxy of a class showing outlying rings or segments of rings of material. NGC 507 lies at $\alpha = 1^{\mathrm{h}}20^{\mathrm{m}}.8$ $\delta = +33°0'$ (1950) which corresponds to $l = 131°$, $b = -29°$. A study of the cluster was undertaken as part of a larger scale program of investigation of possibly related groups in this region of the sky, including the well-known Perseus cluster.

II. OBSERVATIONS AND RESULTS

The region investigated falls within about 0°.5 of NGC 507. Redshifts were determined for 12 galaxies in the area, and published values for two others provide a total of 14. Redshifts were determined from 230 Å mm^{-1} image-tube spectrograms obtained with the Steward Observatory 90-inch (229 cm) telescope at Kitt Peak. All spectra were measured on a single-screw Gaertner measuring engine and reduced by hand. Corrections for Earth orbital motion and galactic rotation (300 km s^{-1}) were applied. Accurate positions for 18 galaxies in the region were determined by measurement of a 90-inch direct plate with respect to astrographic reference stars. Positions should be correct within about 1″. Morphological types were estimated from the National Geographic–Palomar Observatory Sky Survey prints and are uncertain for the smaller compact objects due to the small scale. Magnitudes have been taken from Zwicky and Kowal (1968) when available, or estimated from the sky survey prints when not available. Table 1 contains a summary of the data on the galaxies. Table 2 gives derived positions for the astrographic stars.

The largest differences between redshift values occur between different plates on the same object. Multiple plate intercomparisons using the same observer showed an rms scatter of ± 114 about the means, quite close to the typical uncertainty of ± 100 usually quoted for single spectra. Part of the scatter is due to random grain noise which affects the appearance of the spectrum. Some of the effect, however, appears to arise from small shifts between the comparison and galaxy spectrum due to slightly different magnetic environments and perhaps flexure when they are impressed. The small shifts can be corrected for by use of nightsky line measurements which appear to markedly improve consistency. Such corrections have not been derived or applied to the measures in this paper, however, and will be discussed elsewhere.

III. DISCUSSION

The mean redshift of the 14 galaxies in the NGC 507 sample is 5113 $\pm$ 175 (m.e.), and the rms scatter is 634. This is indistinguishable from the NGC 383 group which lies a few degrees to the west within the same Zwicky cluster. Eight galaxies tabulated by Humason, Mayall, and Sandage (1956) give $V_0 = 5264 \pm 202$ and $\sigma = 534$ for the NGC 383 group. The Perseus cluster 2^{h} east and 8° north of NGC 507 also gives a redshift which is not significantly different, 5460 $\pm$ 200 (m.e.) according to Chincarini and Rood (1971). Several other groups in between also appear to be similar and are under further study. There therefore appears to be a very large interrelated aggregate of galaxies in this region of the sky. In none of the regions studied is there much if any indication of noticeable foreground or background contamination in the galaxy sample. The redshift values in the region imply a distance of close to 70 Mpc for $H = 75$ km s^{-1} Mpc^{-1}.

TABLE 1

NGC 507 Group Galaxies

Ident.	R.A. (1950)	Decl. (1950)	V_0	n, o, m*	Type	m_p	Notes
Anon "5"....	1h20m02s67	+33°15′23″1	4331	1 1 1	E3	(16.0)	1
NGC 494....	1 20 06.53	+32 54 47.1	5513	1 1 2	Sa	13.8	2
NGC 495....	1 20 06.91	+33 12 38.3	4304	0 0 0	SBa	14.0	3
NGC 498....	1 20 22.17	+33 13 43.3	6350	1 1 2	S0	(15.8)	1
NGC 499....	1 20 22.41	+33 11 58.4	4565	0 0 0	S0	13.0	4
NGC 496....	1 20 22.46	+33 16 07.5		0 0 0	Sc	14.3	5
IC 1687......	1 20 30.16	+33 01 01.2	5080	1 2 4	E3	14.8	
NGC 501....	1 20 33.30	+33 10 20.8	5086	1 1 1	E0	15.2	
NGC 504....	1 20 38.93	+32 56 38.0	4288	1 2 3	Sa	14.0	6
NGC 503....	1 20 39.37	+33 04 16.8	6177	1 2 3	E3	15.1	
NGC 507....	1 20 50.89	+23 59 44.4	4935	2 2 4	E1	13.0	7
NGC 508....	1 20 51.50	+33 01 13.3	5674	4 2 6	E1	14.5	8
Anon "2"....	1 20 52.57	+32 56 33.0	5356	1 1 2	E0	(15.9)	1
IC 1690......	1 21 00.51	+32 53 45.4	4735	1 1 1	S0	14.9	
Anon "8"....	1 21 00.88	+33 19 29.0		0 0 0			9
Anon "4"....	1 21 09.36	+33 03 10.9	5193	1 2 2	E3	15.0	
NGC 515....	1 21 49.08	+33 12 46.2		0 0 0	S0	14.3	9
NGC 517....	1 21 54.41	+33 10 11.1		0 0 0	S0	13.6	9

* n = number of spectrograms available, o = number of persons measuring each object, m = number of separate measurements on each object.

Notes to Table 1

1. Magnitude estimated from Sky Survey prints.
2. Nilson (1973) gives a morphological type Sa–Sb. This galaxy shows a normal late type absorption spectrum plus strong 3727 [O II] and N1, N2, [O III] emission. Hβ, normally in emission along with [O III], is not present. Emission and absorption redshifts agree well.
3. V_0 from de Vaucouleurs and de Vaucouleurs (1964) who give morphology as S0. Nilson (1973) gives a morphological type SB0/SBa.
4. V_0 from de Vaucouleurs and de Vaucouleurs (1964), who give morphology as S0. Nilson (1973) also gives a morphological type of S0.
5. Although this galaxy has a fairly bright total magnitude, it is so diffuse that it is nearly invisible on the 90-inch f/9 plates; and no spectrogram was taken. Nilson (1973) gives a morphological type of Sb–Sc; however, the almost total lack of nucleus implies a late Sc.
6. Nilson (1973) gives a morphological type S0.
7. de Vaucouleurs and de Vaucouleurs (1964) give V_0 = 5118 and morphology as E3. Nilson (1973) gives morphology as E. NGC 507 = Arp 229 = VV 207 (see Introduction).
8. Nilson (1973) gives morphology as E.
9. Outside of region observed for spectra, morphology, if given, is from Nilson (1973).

Although the only magnitudes available for the galaxies are total photographic magnitudes from Zwicky and Kowal (1968), it is of interest to examine the redshift-magnitude diagram. Figure 1 shows the result. Although the number of points is certainly small, the diagram is consistent with the band concepts and non-Doppler redshift interpretation set forth by Tifft (1974).

TABLE 2

Astrographic Star Positions

Ident.*	R.A. (1950)	Decl. (1950)
3276..........	1h21m04s92	+32°52′32″1
3291..........	1 19 47.15	+32 56 34.3
3292..........	1 19 53.91	+32 59 50.1
3303..........	1 20 26.17	+33 02 03.7
3304..........	1 21 02.97	+33 03 19.7
3305..........	1 21 04.15	+33 02 16.4
3319..........	1 19 56.66	+33 15 10.3
3320..........	1 20 39.32	+33 11 37.9
3321..........	1 21 24.07	+33 14 34.3
3329..........	1 19 48.97	+33 18 28.1

* Oxford astrographic plate No. 3247.

For completeness a conventional virial-theorem stability analysis was carried out for 14 objects in the NGC 507 region. The virial theorem can be expressed at $2T + \Omega = 0$, where T and Ω represent the time-average kinetic and potential energies of the cluster, respectively. The usual correction factors of $\sqrt{3}$ and $\pi/2$ have been used to correct velocities and separations to true spatial values. The cluster follows the usual pattern for clusters of galaxies investigated in this manner, showing an excess of kinetic energy or a

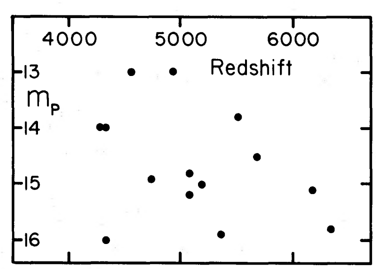

Fig. 1.—Redshift-magnitude diagram for the NGC 507 group core. The diagram is consistent with the presence of bands sloping to greater redshifts at fainter magnitudes.

lack of observed mass depending upon one's viewpoint. The value of $2T/\Omega$ was found to be 4.3, assuming mass-luminosity ratios of 55 and 3 for elliptical and spiral galaxies, respectively. If the M/L ratios for elliptical and spiral members are brought closer together (24 and 7), $2T/\Omega$ is approximately tripled. If more extreme values of M/L (100 and 3) are used, the energy ratio is reduced to 2.3. A trial analysis with the exceptionally massive object NGC 507 absent showed that this object does not dominate the calculations. Thus, varying the uncertain parameters by reasonable amounts does not yield values of $2T/\Omega$ less than 2, with 4 being considered a more likely value.

The virial theorem may also be used to estimate the total mass of the cluster core, M_T. The theorem may be written in the form

$$M_T\langle v^2\rangle_m - GM_T{}^2\left\langle\frac{1}{r}\right\rangle_m = 0\,,$$

where $\langle v^2\rangle_m$ is the mass-average residual velocity and $\langle 1/r\rangle_m$ the mass-average inverse pair separation. Use of this expression gives a total core mass of $6 \times 10^{13}\ M_\odot$. This is approximately one order of magnitude greater than the total photometric mass of the galaxies. Thus, even allowing for uncertainties in the data and in the values of the parameters used in this analysis, it is concluded that the cluster core does not show stability. A similar study of the nearby NGC 383 group of galaxies by Burbidge and Burbidge (1961) drew similar conclusions.

Although arithmetic means are typically used in calculations of average cluster redshift and velocity dispersion, the more correct mass-weighted averages have been used in this analysis. For the NGC 507 group the mass-averaged velocity dispersion is 425 km s^{-1} whereas the straight rms value is 634.

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