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Redshifts for Galaxies in and near Abell 2147

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Sixteen galaxies southwest of the Hercules cluster were observed to determine the true spatial arrangement of two apparent arcs of galaxies. Twelve of them, including the peculiar system Arp 324, are projected against the rich cluster Abell 2147. Four are away from the main body of the cluster. All but two of the group have redshifts comparable to galaxies in the Hercules cluster. A 2147 is at roughly the same distance as the Hercules cluster.

THE region covered by the Palomar Observatory Sky Survey field centered at $\alpha=16^{\text{h}}00^{\text{m}}$, $\delta=+18^{\circ}00'$ contains three rich clusters, A 2147, A 2151 (Hercules), and A 2152 (Abell 1958). All are distance group 1. The clusters appear to overlap and form one large complex of galaxies with the Hercules cluster as a subcondensation.

Abell 2147 is centered at $\alpha(1950)=16^{\text{h}}00^{\text{m}}0$, $\delta(1950)=+16^{\circ}03'$. The peculiar chain Arp 324 (VV 159) (Arp 1966), consisting of two giant D and a number of fainter galaxies, is at the cluster center. A bright E with several companions extends the chain $20'$ to the north. Four minutes west of this configuration there is another north-south chain of galaxies of about the same apparent magnitude as those in A 2147. Galaxies in these two arcs were observed to determine the true spatial arrangement of the system. The area between the two arcs is relatively devoid of galaxies.

I. OBSERVATIONS

The 16 galaxies observed are identified in Plate I, p. 401. Redshift spectra were obtained with the Carnegie image-tube spectrograph attached to the 84-inch telescope of the Kitt Peak National Observatory on four nights, 19-22 June 1971. The dispersion was 250 \AA/mm and optimum focus was set at 4200 \AA . Exposure times on unbaked IIA-O plates ranged from 45 to 60 min.

The spectra were measured on the KPNO digitized Grant comparator and reduced on the CDC 6400 using the FORTRAN program written by N. B. Sanwal.

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The average probable error of a heliocentric radial velocity is estimated at about 75 km/sec. A correction of $+94 \text{ km/sec}$ for the run was derived from observations of standard stars and applied to the measured galaxy redshifts.

The spectra are all late type and show *H* and *K* absorption and most showed the *G* band. The spectra of NGC 6018 and of the central component of Arp 324 showed 3727 in emission. The corrected heliocentric velocities are given in Table I. Column 1 is the identification number from Plate I; columns 2 and 3, the coordinates from Zwicky and Herzog (1963); column 4, the galaxy name; and column 5, the velocity.

II. DISCUSSION

The redshifts for 14 galaxies in this group are in the range 9200-13 200 km/sec. The average for these is 11 208 km/sec, heliocentric, or approximately 11 330 km/sec, corrected for solar motion. The Burbidges (1959) found an average of 10 775 km/sec for 15 galaxies in the Hercules cluster, which is at a projected separation of 2° from A 2147. The two clusters are at approximately the same distance and form one large complex of galaxies. NGC 6018 and 6021, in the southwest corner of the grouping, have redshifts less than half that of A 2147 and are foreground objects.

Three members of Arp 324 (VV 159) were observed in this program. The redshifts were 10 483, 13 170, and 10 497 km/sec for the northern, central, and southern components, respectively. These values are in good agreement with those of Sargent (Burbidge and Sargent 1971) who measured 10 402, 13 242, and 10 548 km/sec for the same objects. This is a possible case of a system with one discrepant redshift because the two

TABLE I. Heliocentric radial velocities in and near A 2147.*

No.	α_{1950}^\dagger	δ_{1950}^\dagger	Name	V
1	15 55.2	+16 00	NGC 6018	5121
2	15 55.2	+16 05	NGC 6021	4486:
3	15 55.5	+16 25	NGC 6022	11225
4	15 55.5	+16 27	NGC 6023	11140
5	15 58.3	+15 50	IC 1155	10629
6	15 58.6	+16 28		12346
7	15 59.8	+15 50	Bright	10136
8	15 59.8	+15 50	Faint	10109
9	15 59.9	+16 02	Arp 324	10497
10	15 59.9	+16 04	Arp 324	13170
11	15 59.9	+16 34		9276
12	16 00.0	+16 06	Arp 324	10483
13	16 00.0	+16 17		12894
14	16 00.0	+16 30		12054
15	16 00.0	+16 29		11449
16	16 01.2	+16 28		11497

Notes to Table I

* A 2147 center at $\alpha_{1950} = 16^h00^m00^s$; $\delta_{1950} = +16^\circ03'$.

† Co-ordinates from Zwicky and Herzog.

No. 1. 3727 emission.

No. 2. Plate measured in one direction only.

No. 9. 3727 emission.

giant components have smaller velocities than the fainter, compact one.

Gary Welch kindly obtained a IIIa-J plate of Arp 324 with the Palomar 48-inch Schmidt to search for an optical connection among the galaxies. An isodensitracing of his plate is shown in Plate II. Both of the giant D galaxies have extended envelopes, elongated along the direction of the chain. There is a slight suggestion of a connection between the northern and central components. The envelope of the southern D extends about 2' north and 2' south so that one cannot say whether the overlap with the central galaxy is a physical connection or a projection effect. There does appear to be an optical link between the southern D and the spindle galaxy to the southwest. No redshift is available for the latter.

III. CONCLUSION

The western of the two chains is apparent only. Two of the four galaxies observed are foreground objects on the basis of their much smaller velocities. The northern two have velocities which indicate that they are outlying members of A 2147. The eastern configuration is made up of the prominent members of A 2147.

The situation remains ambiguous, as to the source of the larger redshift for the central galaxy in Arp 324. The spectrogram has 3727 in emission and the optical appearance of the galaxy is that of an irregular, high-surface-brightness object with a very steep edge gradient of intensity. The velocity was higher than for any other object in the group but it is not outside the possible range of velocities in a rich cluster.

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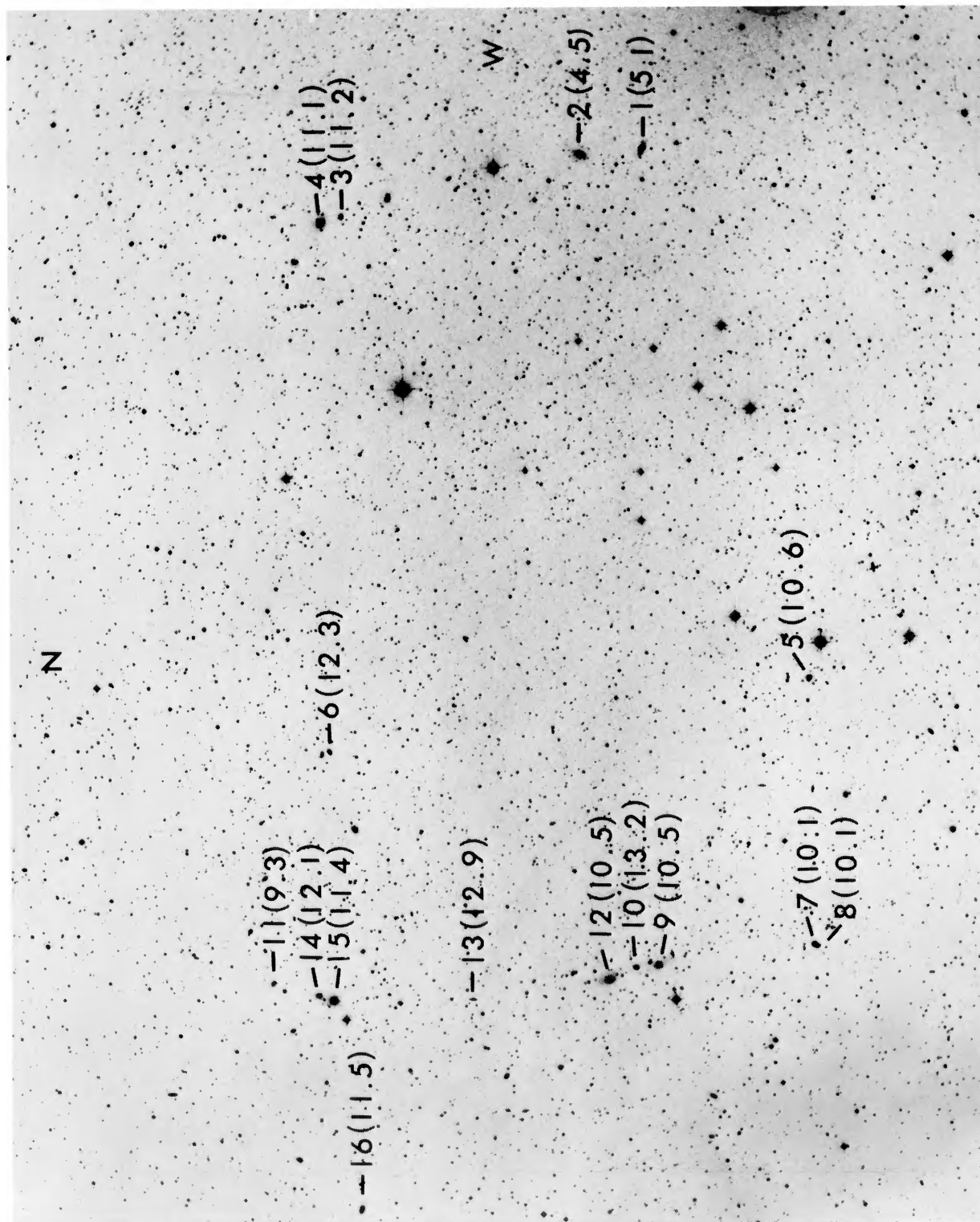


PLATE I (Bautz, p. 331). Identification chart for the galaxies observed in and near A 2147. The numbers in parentheses are the redshifts in thousands of km/sec. Nos. 8, 9, and 11 form part of Arp 324. (Copyright *National Geographic Society-Palomar Observatory Sky Survey.*)

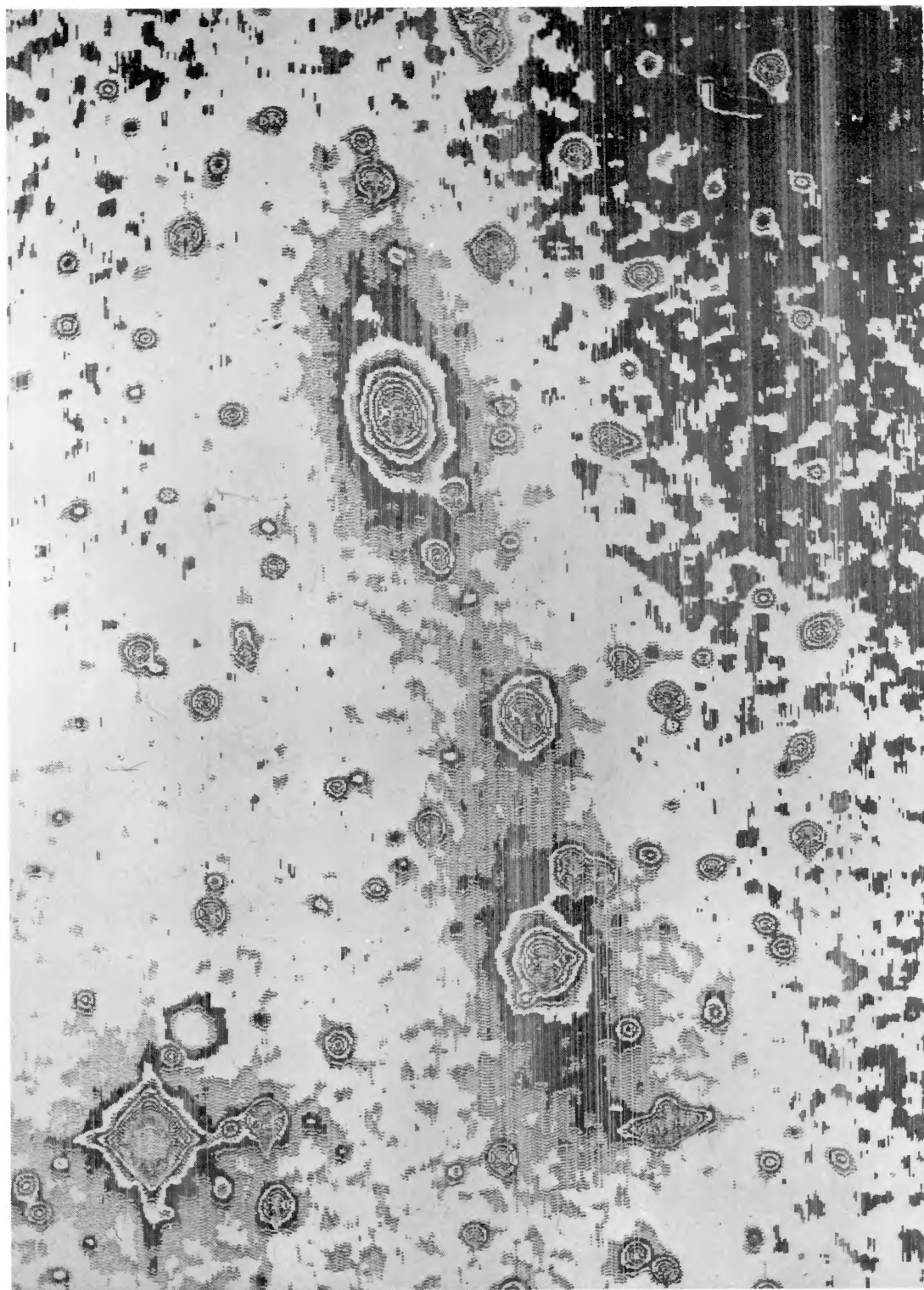


PLATE II (Bautz, p. 331). Isodensitration of a IIIa-J plate of Arp 324 taken by Gary Welch with the Palomar 48" Schmidt. North is at the top, east is to the left.