The Fornax Dwarf Galaxy. I. The Globular Clusters

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Two new globular clusters have been found to belong to the Fornax dwarf galaxy. The properties and dimensions of the five known globular clusters are comparable to those of our galaxy. Measures of individual stars in each indicate that the magnitudes of their brightest stars are identical within 0.1 mag., but that the brightest stars of the main galaxy are 0.5 mag. brighter. The globular clusters have nearly ten times the projected star density of the main galaxy.

SHORTLY after Shapley's discovery (1938) of the nearby dwarf elliptical galaxy in Fornax, he published the positions of three globular clusters apparently associated with this galaxy (1939). Two of these clusters were investigated by Baade and Hubble (1939), who used the Mt. Wilson 100-inch reflector.

Neither the 100-inch telescope nor Harvard's 60-inch reflector, used by Shapley, has a large enough field to photograph the entire galaxy on one plate. Therefore it was thought worthwhile to re-examine the Fornax dwarf with plates of the ADH Baker-Schmidt, which has both a large field and a faint magnitude limit. Two long-exposure ADH plates, taken without filter, were examined in 1957, and then a series of very long-exposure blue and visual ADH plates was taken of the Fornax galaxy when the writer was in South Africa in 1958. In addition, he has taken a few plates of the galaxy with the 48-inch Schmidt of the Palomar Observatory.

THE NEW CLUSTERS

In addition to the three previously known globular clusters, two new ones were found on the plates. All five are listed and described in Table I. Figure 1 reproduces a portion of a 75-minute exposure ADH plate, on which the globular clusters are identified.

TABLE I. Globular clusters of the Fornax dwarf galaxy.

Number	α(1950)	δ(1950)	Conc. class	Diam.
1	$2^h\ 35^m.0$	$-34°\ 23'$	XI	0'.6
2	2 36.6	−35 01	VIII	0.6
3 (NGC 1049)	2 37.8	−34 29	V	0.6
4	2 38.1	−34 45	IV	0.4
5	2 40.4	−34 21	III	0.5

Of the new clusters, No. 5 is the brighter and the nearer to the center of the galaxy. Its distance of 40′ from the center places it just within the outermost contours of the star distribution of the galaxy, as determined from counts on the Schmidt plates. It lies outside the boundaries of the galaxy as determined by Shapley (1939) or Baade and Hubble (1939) from large-reflector plates. Cluster No. 5 is very heavily concentrated towards its center, and appears nearly stellar on plates of the 24-inch Bruce camera.

The other new cluster, No. 1, is unusually open and poor in stars. It has a very irregular appearance, but is quite certainly a globular cluster, for its brightest stars are similar in magnitude and color to those of the other four globulars. Cluster No. 1 is 43′ distant from the center of the Fornax galaxy and lies about 5′ from the outermost portions of the galaxy traceable from star counts.

It seems unlikely that any further globular clusters will be found to be members of the Fornax dwarf. The sky within 2° of the center of the system was thoroughly searched on ADH plates with a limiting photographic magnitude of about 20, without additions to the present list.

A very faint object, just 7′ north of cluster 4, was mentioned by Shapley (1939) as a possible cluster of the system. It is unresolved on all the Schmidt plates, and is probably rather bluer than the globular clusters. On 200-inch plates taken by Baade and kindly shown to the writer by Miss Swope, this object appears as a group of five stars of approximately 21st mag. They appear to have the color of the neighboring stars of this magnitude.

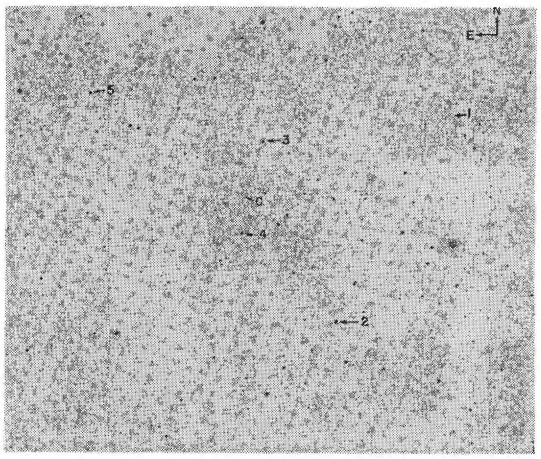

FIG. 1. The Fornax dwarf galaxy. The five globular clusters are numbered. The group of very faint stars is designated by C. From a blue photograph taken with the ADH Baker-Schmidt telescope.

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DIAMETERS

Table I lists the angular diameters of the globular clusters as judged on the deepest Schmidt plates. Such estimates are useful in giving bases for rough comparisons. All of the clusters are seen to be very similar in size. If we accept Baade and Hubble's (1939) distance for the system as 180 kpc, the mean cluster diameter of 0.5′ corresponds to 30 parsecs. This agrees well with sizes of globulars in the Galaxy, but is smaller than values for intergalactic tramp globulars (Burbidge and Sandage, 1958). It should be mentioned that Baade and Hubble's distance remains the best available estimate. The distance given by Allen (1956), 290 kpc, results from an incorrect application of the 1952 distance-scale revision which does not apply to the Fornax galaxy.

MAGNITUDES

From photographic transfers, Baade and Hubble (1939) were able to determine an approximate value of 19.67 for the photographic magnitude of the 6th brightest star in the globular NGC 1049. The writer has measured with an Eichner astrophotometer the brightest stars of all five objects to determine how well they agree. Because of the lack of a photoelectric sequence, approximate magnitudes were obtained using Baade and Hubble's magnitude for a zero point and sequences on other ADH plates for the slope of the calibration curve. Though not well calibrated, the present material is uniform, and can be used to detect differences in the level of the brightest stars of different clusters. Such a test is of considerable interest in the light of recent evidence (Sandage and Wallerstein 1960) that the brightest stars among globular clusters may differ considerably in magnitude, as a function of chemical composition. The magnitudes given in Table II show that for the five clusters of the Fornax system, the brightest stars are all very nearly the same, the difference being no greater than 0.1 mag. Crowded images prevented the detection of any possible smaller differences in brightness. However, the data easily show that differences as large as those discussed by Sandage and Wallerstein do not exist for the Fornax system globular clusters. This fact indicates that the globulars in Fornax are probably uniform in age and chemical composition, a condition which seems reasonable for such a uniform and featureless system as an elliptical galaxy.

COMPARISON WITH MAIN GALAXY

The brightest stars in the main galaxy itself are considerably (approximately 0.5 mag.) brighter, than any stars of the globular clusters. This fact is important to the problem of determining distances to such objects, if mean globular-cluster characteristics are applied to elliptical galaxies. The difference may be a consequence of the far greater population of the galaxy, where unusually bright stars are statistically more plentiful. Star counts indicate that to the approximate limiting magnitude pg = 19.9, the Fornax galaxy contains nearly 10 000 stars, while the globular clusters each contain fewer than 20 to this limit. However, the luminosity function of M3 determined by Sandage (1954) is so steep at the bright end that a simple multiplication of it by 500 does not increase the number of stars sufficiently to raise the upper brightness limit by more than 0.1 mag. It seems necessary to conclude that the observed difference of 0.5 mag. is not a straightforward result of the greater population of the galaxy, but results from differences in the shapes or levels of the color-magnitude diagrams of clusters and galaxy.

A further conspicuous difference between the parent galaxy and its globular clusters is in their star densities. On a blue plate with the approximate faint limit of 19.9, the projected density of stars in the most dense portions of the Fornax galaxy is 9 stars per square minute, while that for the globular clusters averages 80 stars per square minute.

The Fornax dwarf, with its globular clusters, is an ideal object for studying differences between elliptical galaxies and globular clusters. The present work indicates that the differences are not trivial, and that color-magnitude diagrams of these objects are of great desirability.

TABLE II. Magnitudes of brightest stars in clusters.

Cluster	Magnitude (pg)
1	19.7
2	19.6
3 (NGC 1049)	19.6
4	19.7
5	19.6
main galaxy	19.1

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