OBSERVATIONS OF FAINT GLOBULAR CLUSTERS

L. ROSINO and G. PINTO
Astrophysical Observatory, Asiago, Italy

The present communication reports some results of observations made at Asiago on three faint globular clusters discovered on Palomar Sky Survey plates (Abell 1955).

Palomar 2 ($4^h43^m.1$, $+31°23'$, 1950; $l=170°$, $b=-9°$). This cluster was studied some years ago by McCarthy and Treanor (1964) on infrared plates taken with the Schmidt telescope of the Vatican Observatory. After an extensive discussion the authors concluded that the object was either a peculiar globular cluster at an estimated distance of 63 kpc or an old galactic cluster at a distance of the order of 16 kpc.

In 1957–58 a series of infrared photographs (IN hypersens. + RG5) were obtained at Asiago at the newtonian focus of the 122 cm telescope, and one plate was taken in 1969 with an RCA-Carnegie S1 image tube through an RG8 filter. Some blue and yellow (103a-D + GG11) plates were also available.

The cluster is scarcely visible on the blue plates; it becomes more clear in yellow and quite sharp in infrared light (Figure 1). Its structure, on the infrared plates, is that of a globular cluster with a moderate concentration. Comparison with other distant underexposed globular clusters shows that the general structure is the same. The apparent diameter has been estimated to be about 3′, but the cluster would certainly become larger if the faintest components, weakened by strong interstellar absorption, and barely visible in the infrared, should emerge. More than 150 stars have been counted on the Asiago infrared plates within 90″ of the centre of the cluster, of which at least 20 are 1.5 mag. brighter than the plate limit.

Assuming tentatively a linear diameter between 20 and 40 pc, which seems reasonable for a globular cluster of intermediate size, with an apparent diameter of 3′ a distance of between 23 and 46 kpc is obtained, corresponding to a median distance modulus of about 17.4. Considering the deep absorption in the direction of the cluster, at least 2 mag. in the blue, it is very unlikely that the horizontal branch can be reached with the Asiago telescope, even in the infrared.

The cluster has been carefully examined at the blink for the finding of variables, but the result has been negative: no variables have been found. Since the plates cover a period longer than one year, it is likely that the cluster does not contain red variables of the semiregular or long period type. However, the possibility that RR Lyrae variables may be present cannot be ruled out.

Palomar 4 ($11^h27^m.1$, $+29°12'$, 1950; $l=202°$, $b=+72°$). Two slow variables have been discovered in this extremely faint cluster by Rosino (1957) and by Burbidge and Sandage (1958), who determined the *c-m* diagram and remarked on its peculiarities. The horizontal branch is almost absent, being reduced to a short red stub, although

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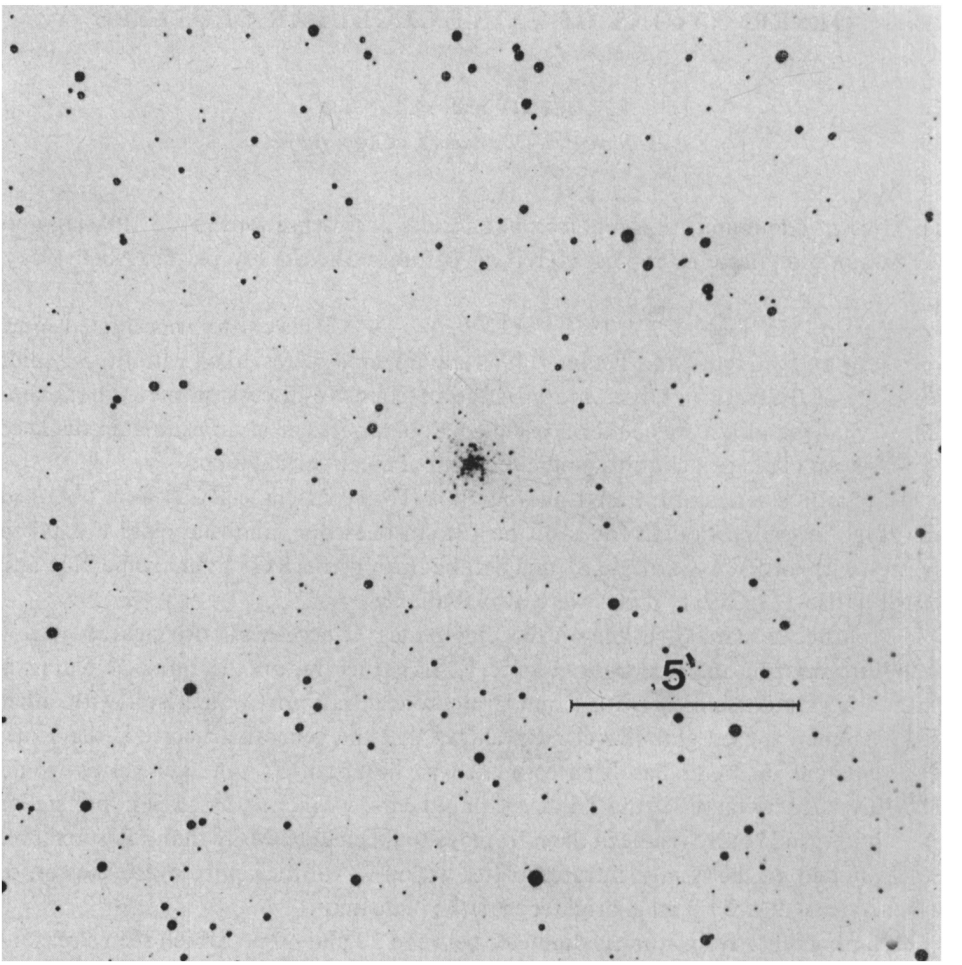

Fig. 1. The globular cluster Pal. 2. Infrared IN hypers. + RG5, 122 cm tel. north at the top.

the ΔV at $B-V=1.4$ is about 2.7. The two red variables are located at the top of the giant branch.

In his previous paper Rosino estimated that the periods of the variables were about one-hundred days. Burbidge and Sandage gave periods of $131^{d}.6$ for Var. 1 (their star No. 44) and $166^{d}.7$ for Var. 2 (star No. 25).

The present observations are reported in Table I. The magnitudes of the variables have been estimated on fourteen blue plates obtained between 1963 and 1967 (one in 1972) with the 122 cm telescope, and from some of the best blue photographs taken with the 67 cm Schmidt in 1971–72. Fourteen infrared Schmidt photographs (IN hypersens. + RG5) were also available.

In the reduction of the blue material (103a-O without filter) the same comparison sequence has been used as in the previous paper. Eye estimates of the magnitudes have

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TABLE I

Magnitudes of variables No. 1 and 2 in Palomar 4

Date	UT	JD	No. 1	No. 2	
1963 Feb 26	23^h08^m	243 8087	19.5	19.0	Newt.
Mar 24	22 20	8113	19.55	19.35	
1964 Feb 12	23 58	8438	18.3	19.3	
Mar 7	22 52	8462	–	17.95	
Mar 9	22 36	8464	19.7	17.9	
1965 Apr 1	00 55	8852	19.2	18.7	
1966 Jan 20	22 15	9146	19.6	18.6	
Mar 2	3 25	9187	17.8	19.0	
Mar 14	21 55	9199	17.75	19.35	
Mar 21	2 39	9206	17.85	19.3	
1967 Feb 16	1 18	9538	19.1	19.1	
Mar 13	22 38	9563	18.05	18.2	
Mar 15	22 58	9565	17.95	18.15	
1971 Mar 2	00 02	4 1013	17.5:	–	Schmidt
Mar 3	00 25	1014	17.9:	–	Schmidt
1972 Feb 12	1 44	1360	18.8:	19.2:	Schmidt
Mar 20	0 16	1397	17.65	18.1	Newt.
May 2	20 36	1440	–	18.15:	Schmidt

been made independently by Bianchini and Rosino. The mean value of the estimated magnitudes is reported in Table I. The elements and light curves have been determined by Pinto with an electronic computer. The elements of the two variables are:

$$\text{Var. 1: } T = \text{JD } 243\,5922 \qquad P = 130^d.50$$
$$\text{2: } \qquad 5938 \qquad 109.30.$$

The light curves are shown in Figure 2. The elements of Var. 1 also satisfy the observations of Burbidge and Sandage, after a correction of -0.5 is made to their magnitudes, which takes into account the different system of comparison stars. In the light curve the observations of Burbidge and Sandage are marked with open circles.

The elements of Var. 2 represent fairly well the old and new observations of Asiago, but some of the magnitudes given by Burbidge and Sandage do not fit the mean light curve.

The dispersion observed in the light curves may be partly due to errors of observation, the variables being very weak on the Asiago material, and partly to the fact that the two stars are semiregular and do not repeat the same light curve from cycle to cycle.

As shown in Figure 2, Var. 1 has an amplitude of $2^m.2$ pg between 17.6 and 19.8 pg (mean values); Var. 2 has amplitude of $1^m.8$ between 17.6 and 19.4 pg. Median pg magnitudes: 18.7 and 18.5. The variables have also been estimated on the Schmidt infrared plates. They are the brightest components of the cluster, even at minimum. Var. 1 has an infrared amplitude of about $0^m.9$; Var. 2: $0^m.85$. The $B-I$ color index increases from maximum to minimum.

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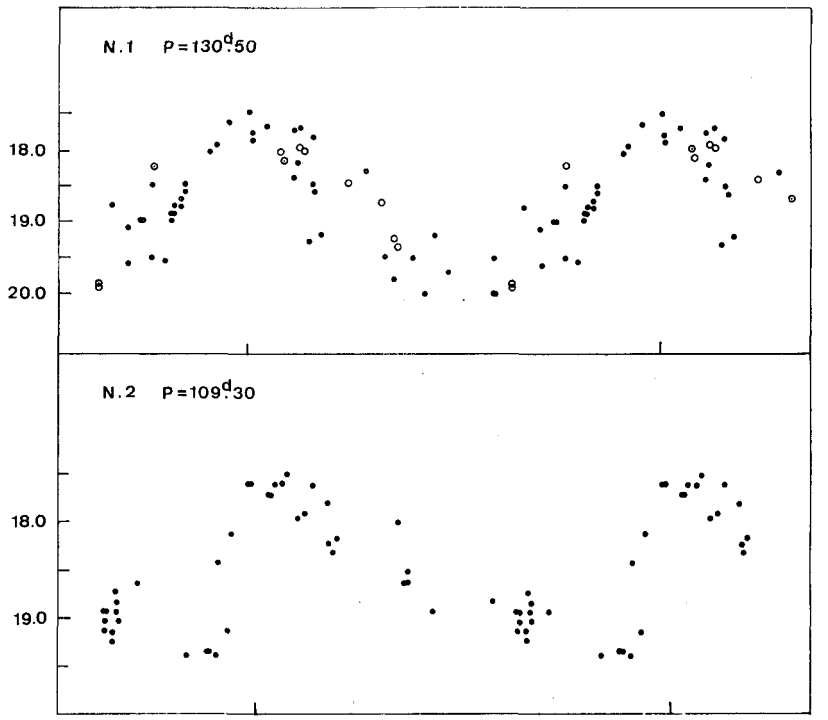

Fig. 2. Light curves of Var. No.1 and No.2; circles indicate Palomar observations corrected by −0.5.

With a mean median pg absolute magnitude −2.4 (if a distance modulus of $m-M=$ $=21$ is adopted for the cluster) and periods between 100 and 150 days, the two variables can be classified as red semiregulars, a type which is not uncommon in globular clusters with a relatively high metal abundance.

Palomar 5 ($15^h13^m.5$, $+0°5'$, 1900; $l=1°$, $b=46°$). This giant-poor cluster was discovered by Baade in 1950 on Palomar Schmidt plates. Five RR Lyrae variables were later found by Rosino (1951), and their periods determined by Pietra (1956) and Mannino (1956). The elements have been slightly improved by Kinman and Rosino (1962) as follows:

Var. 1	$P=^d.0293230$	Ampl. 0.42 B
2	.332467	0.40
3	.329953	0.40
4	.286362	0.48
5	.252395	0.30.

The peculiarity of this cluster, besides its looseness and the scarcity of giant stars, is the fact that it contains five RR_c Lyr variables without any RR_{ab} stars, a case which is *unique* among globular clusters.

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Other photographs of the cluster have been taken at Asiago since 1962. The magnitudes determined by examing the new material fit perfectly the light curves obtained with the preceding elements. However, a tentative attempt has been made by one of us (G.P.) to see whether some alternative period, larger than $0^d.6$, might fit all the observations. The result has been completely negative. It is therefore confirmed that the five RR Lyrae variables of this cluster are all of type *c*.

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