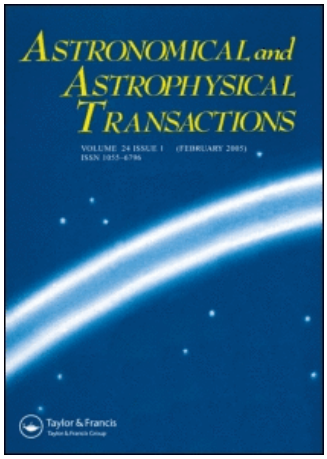

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Galactic clusters and DDO photometry

A. V. Loktin [a]
[a] Astronomical observatory of Ural University, Ekaterinburg, Russia

Online Publication Date: 01 January 1996
To cite this Article: Loktin, A. V. (1996) 'Galactic clusters and DDO photometry', Astronomical & Astrophysical Transactions, 9:2, 95 - 101
To link to this article: DOI: 10.1080/10556799608208215
URL: http://dx.doi.org/10.1080/10556799608208215

Astronomical and Astrophysical Transactions, 1995, Vol. 9, pp. 95–101
Reprints available directly from the publisher
Photocopying permitted by license only

GALACTIC CLUSTERS AND DDO PHOTOMETRY

A. V. LOKTIN

620083, Astronomical observatory of Ural University, 51, Lenin av., Ekaterinburg, Russia

(Received January 4, 1994)

The photometric data in DDO system from the literature are used to get new estimates of reddenings, distances, and metallicities for 42 galactic clusters. The errors of these estimates are considered, the discussion is based on the comparison of DDO values with the data we have got using UBV data. The validity of cluster parameters calculated from DDO data is discussed.

1 INTRODUCTION

The observed color indices of well known DDO photometric system (see e.g. Straizys, [1]) allow estimates of reddening, luminosity, and metallicity of individual red giant stars. A large fraction of galactic clusters, especially of old and intermediate age, include red giants as their members, and DDO photometry is succesfully used to estimate parameters of these clusters. It is worth noting that the photometric technique makes it possible to create a large and homogeneous (in the sense of method used) set of cluster metallicities appropriate for the investigation of galactic disk chemical evolution, which can hardly be done now by the spectroscopic method.

During the recent years the author with collaborators are fulfilling a program of reevaluation of parameters of galactic clusters using published UBV data. The first version of the new catalogue will be published soon (Loktin, Matkin [2]). By now we have evaluated characteristics for more than 340 objects, and this version has been sent to the Strasbourg Centre of Stellar Data. In order to extend the volume of the catalogue by new independent data, especially to enrich the set of metallicity estimates, we decided to use DDO photometry to get new information on open cluster parameters.

2 DATA AND METHOD

The inspection of published literature provided us by the list of 62 clusters with at least one star is observed in the DDO photometric system. To estimate cluster red

giant parameters, we use the standard procedure described by Janes [3], [4], with some developments, and we have compiled a computer program where the calibration tables from Janes's papers are presented as a sets of polynomials. The main development concerns the evaluation of [Fe/H] from δCN, which is the metallicity index of the DDO system. To calculate the values of [Fe/H] from δCN, we use the following expression:

$$[Fe/H] = -0.197 + 3.001 \cdot \delta CN - 8.98 \cdot (\delta CN)^2,$$

the details of evaluation of this expression one can get from the author's previous paper [5]. It is worth noting that the formal root mean square error of prediction of [Fe/H] from this expression is equal to 0.09 dex, which promises good internal quality of the mean metallicity estimates for clusters. The translation from the values of $E(B-V)$ to excesses of color indices of the DDO system is fulfilled using the values of coefficients taken from [8].

The results of estimating parameters for 42 clusters are given in Table 1. 49 independent sources have been used for our calculations. In order to avoid crude errors in estimates of parameters caused by cluster nonmembers we use only sources where DDO data exist for at least three stars. The references to photometry sources will be given in our new catalogue uniting estimates from of UBV, DDO, and uvby β photometric systems which is now in preparation.

We calculated the mean cluster parameters in the following way. After the first calculation of star parameters, we rejected obvious nonmembers from the samples on the base of their discordant color excesses or distance moduli and prepared the first list of mean cluster parameters. Table 1 lists the mean parameter values calculated using weights inversely proportional to deviations from the first mean values. The first column of the Table gives cluster names, clusters being arranged in ascending order of galactic latitude. The second column gives the number of stars used for parameter determination. The estimated values of $E(B-V)$ and the errors of the mean for these estimates are given in the 3rd and the 4th columns. The same for distance moduli are given in the 5th and the 6th column, and for the estimates of values of [Fe/H], in the 7th and the 8th columns. The last, 9th column contains the age logarithms if they exist in our catalogue [2].

3 COMPARISONS

To check up our results of redetermination of cluster parameters, we have compared them with the data of the above-mentioned catalogue [2]. The catalogue contains 34 clusters common with Table 1, and the comparison between estimates of color excesses and distance moduli we have got from DDO data here and from UBV data is shown in Figures 1 and 2. In the cases when two or more sourses of DDO photometry are available the results are considered as separate.

The comparison between the estimates of reddening $E(B-V)$ is shown in Figure 1. It is evident from Figure 1 that the systematic error between the two sets of

Table 1. Estimates of open cluster parameters from data of DDO photometry

Cluster	*N*	$E(B-V)$	*err.*	*Mod.*	*err.*	*[Fe/H]*	*err.*	*log t*
NGC6494	5	0.38	0.05	8.84	0.51	–0.03	0.01	8.53
NGC6791	7	0.08	0.02	14.78	0.18	–0.10	0.02	–
NGC7789	22	0.23	0.01	12.37	0.25	–0.31	0.02	–
NGC188	10	0.06	0.01	12.35	0.14	–0.21	0.03	9.82
NGC752	8	0.02	0.01	8.78	0.09	–0.25	0.01	9.43
NGC752	11	0.01	0.00	8.23	0.13	–0.24	0.02	9.43
NGC2099	5	0.29	0.01	10.01	0.48	–0.08	0.03	8.50
NGC2158	6	0.36	0.02	13.55	0.43	–0.49	0.05	–
NGC2420	13	0.04	0.01	12.44	0.21	–0.38	0.02	9.32
Praesepe	5	0.01	0.00	6.85	0.09	–0.04	0.02	8.84
NGC2232	5	0.05	0.02	7.93	0.57	–0.22	0.06	7.59
M67	36	0.04	0.00	9.70	0.08	–0.13	0.01	9.72
M67	24	0.04	0.00	9.58	0.07	–0.13	0.01	9.72
NGC2204	16	0.09	0.02	12.04	0.30	–0.31	0.05	–
NGC2548	5	0.05	0.01	9.71	0.32	–0.17	0.07	8.54
NGC2423	4	0.11	0.01	9.69	0.16	–0.10	0.05	8.76
NGC2506	12	0.09	0.01	12.50	0.29	–0.47	0.03	9.07
NGC2287	7	0.07	0.01	8.59	0.20	–0.22	0.06	8.40
NGC2539	13	0.06	0.01	10.60	0.11	–0.11	0.02	8.77
NGC2243	6	0.05	0.02	12.60	0.27	–0.52	0.06	–
NGC2482	3	0.11	0.01	10.69	0.25	–0.03	0.01	8.54
NGC2567	3	0.00	0.00	10.93	0.20	–0.09	0.00	8.43
NGC2567	5	0.12	0.01	10.97	0.24	–0.18	0.06	8.43
NGC2451	7	0.08	0.02	5.50	0.33	–0.17	0.04	8.00
NGC2451	9	0.12	0.01	8.77	0.35	–0.22	0.03	8.00
NGC2477	4	0.28	0.01	9.97	0.18	–0.02	0.02	8.95
Mel66	8	0.12	0.01	13.42	0.36	–0.43	0.04	–
Pis4	3	0.01	0.01	8.59	0.59	–0.22	0.04	7.61
NGC2660	13	0.34	0.02	12.23	0.32	–0.36	0.05	–
NGC2516	3	0.15	0.02	6.87	0.32	–0.23	0.08	7.79
NGC2972	3	0.30	0.02	11.58	0.45	–0.30	0.02	8.37
NGC3114	13	0.14	0.01	9.94	0.21	–0.15	0.02	7.93
Cr223	5	0.11	0.03	10.50	0.46	–0.21	0.07	7.55
NGC3680	9	0.08	0.01	9.46	0.14	–0.19	0.02	9.53
NGC3532	12	0.08	0.01	7.96	0.18	–0.14	0.02	8.41
NGC3960	6	0.29	0.02	11.87	0.24	–0.27	0.03	–
NGC5316	7	0.29	0.02	9.88	0.32	–0.23	0.07	8.16
NGC5617	6	0.34	0.08	9.34	0.63	–0.16	0.03	7.57
NGC5662	3	0.37	0.00	8.54	0.06	–0.49	0.13	8.05
NGC5823	6	0.01	0.02	11.39	0.65	–0.40	0.04	9.22
NGC5822	14	0.09	0.01	9.89	0.22	–0.15	0.02	8.95
NGC5822	14	0.13	0.01	10.15	0.20	–0.15	0.02	8.95
NGC5822	6	0.15	0.02	10.20	0.44	–0.13	0.04	8.95
NGC6067	10	0.46	0.01	9.57	0.35	–0.05	0.02	7.97
NGC6134	11	0.35	0.01	9.91	0.16	–0.05	0.01	9.21
IC4651	14	0.13	0.01	10.14	0.17	–0.06	0.01	9.52
NGC6281	3	0.17	0.01	7.60	0.53	–0.07	0.02	8.45
NGC4349	7	0.36	0.01	11.60	0.31	–0.20	0.02	8.46
NGC4349	7	0.33	0.03	11.88	0.38	–0.22	0.04	8.46

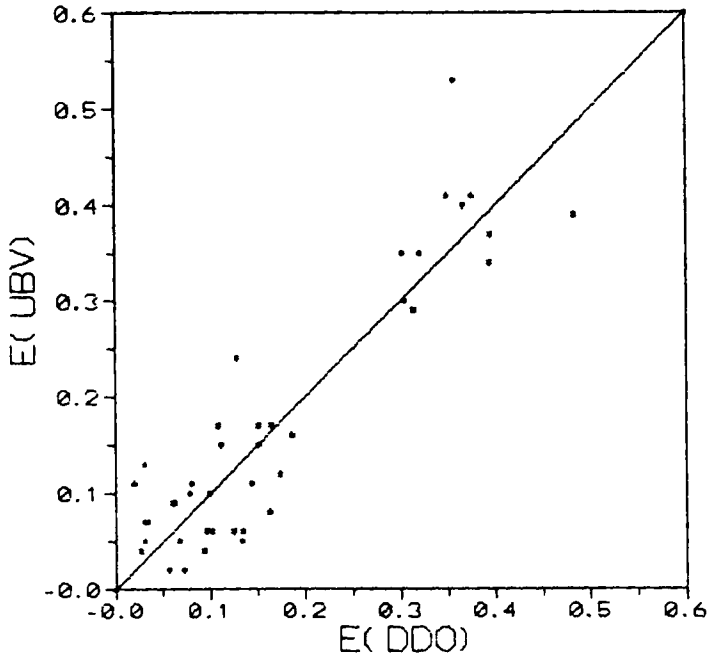

Figure 1 Comparison between the estimates of $E(B-V)$ derived from UBV and DDO data for 42 open clusters. The 45° line is shown by a straight line.

estimates is absent. But the scatter of points about the 45° line is essential even for the case small reddenings. The r.m.s. error of determination of color excess for one star of our sample appears to be equal to $0^m.038$, this value is small and leads to small errors of the mean values (see Table 1) and cannot account for appreciable scatter seen in Figure 1. This scatter can partly be explained for some clusters by the presence of nonmembers and, what may be the main souse of the scatter, by the systematic differences in the DDO systems of various investigators.

The comparison between the two sets of distance moduli (see Figure 2) rèveals that (a) the DDO system of distances is slightly shifted relatively to the UBV system of our catalogue [2] in the sense that moduli determined from UBV data are larger than those determined from DDO data on average by $0^m.25$. This is clearly seen in Figure 1 – the number of points in the part of the figure above the 45° line is smaller than that in the lower part. The resulting systematic correction has been introduced into the values presented in Table 1. The systematic trend with distance is absent (the corresponding hypothesis can be rejected at the significance level of 0.0994). But the scatter of points in Figure 1 is large, and the main source of this scatter is DDO photometry, including probable errors of the DDO system realization. From the inspection of errors given in Table 1 one can see that the mean error of distance modulus determination for one star is equal to $0^m.6$, which is of the order of the dispersion of absolute magnitudes of red giants of the type usually observed in DDO

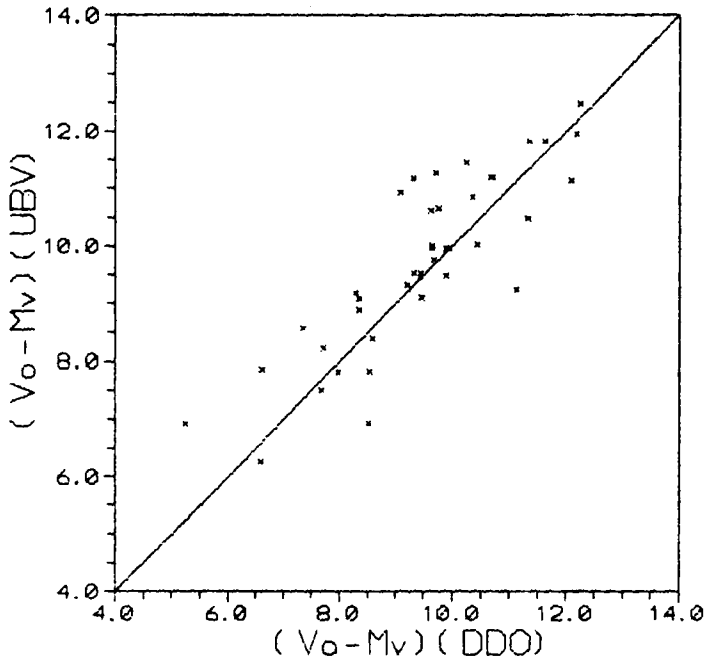

Figure 2 Comparison between the estimates of distance moduli derived from UBV and DDO data for 42 open clusters. The 45° line is shown by a straight line.

system. The same value of r.m.s. error was found by Flynn and Mermilliod in [6]. Certainly this is an upper estimate of the error because of membership difficulties. The best investigated clusters such as M67, Praesepe etc. possess smaller values of these errors, which is seen in Table 1.

Our catalogue [2], being based only on UBV photometry data, does not contain enough metallicity estimates to compare them with metallicities calculated from DDO photometry, and the accuracy of metallicity estimates from UBV data is very low. But Strobel [7] gathered the values of metallicity for a number of open clusters, and we can use this list for our purposes. 30 clusters of our list have also metallicities in [7], and the comparison between these values is shown in Figure 3. The correlation between the two sets of metallicities is clear in spite of appreciable scatter, and the systematic deviation between the two sets of estimates is insignificant. But our scale of metallicities calculated from DDO data is appreciably compressed with respect to Strobel's scale. The use of least squares method gives such an expression for the connection between the two systems of metallicities:

$$[Fe/H]_{\mathrm{DDO}} = -0.14 + 0.43 \cdot [Fe/H]_{\mathrm{Strobel}},$$

and vice versa,

$$[Fe/H]_{\mathrm{Strobel}} = +0.13 + 1.38 \cdot [Fe/H]_{\mathrm{DDO}}.$$

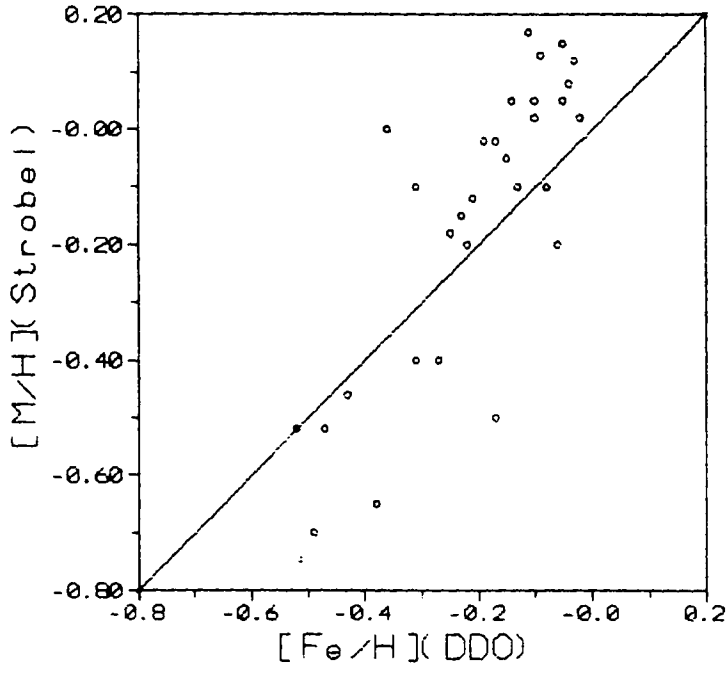

Figure 3 Comparison between the estimates of metallicity $[Fe/H]$ derived in this work and those gathered by Strobel [7] for 30 open clusters. The 45° line is shown by a straight line.

DISCUSSION

The open cluster parameters estimated from DDO photometry lead us to the conclusion that the photometry in the DDO system can provide good internal quality estimates of reddening and metallicity, and if the reduction of photometry is done carefully, the external quality will be high. For the evaluation of distance, one has to use rather many stars because of low accuracy of distance estimates from observed color indices of the DDO photometric system. Probably systematic errors of the photometry play the main role in the accuracy of reddening and distance determinations.

There are many intermediate age and old galactic clusters containing red giants but not observed in the DDO system, so new observations are needed to extend the lists of homogeneously determined metallicities of clusters for the investigation of chemical evolution of the Galaxy.

References

1. Straizys, V. (1977) *Multicolor Stellar Photometry*, Mokslas Publishers, Vilnius.
2. Loktin, A. V., Matkin, N. V. (1993) *Astron. Astrophys. Trans.* (in press).
3. Janes, K. A. (1975) *Astrophys. J. Suppl. Ser.* **29**, 161.

4. Janes, K. A. (1977) *Publ. Astron. Soc. Pacif.* **84**, 576.
5. Loktin, A. V. (1993) *Pisma v Astron. Zhurnal* (in press).
6. Flynn, C., Mermilliod J.-C. (1991) *Astron. Astrophys.* **250**, 400.
7. Strobel, A. (1987) 10th *Europ. Reg. Astron. Meet. IAU*, Praha, August 24–29, p. 129.
8. Janes, K. A. (1979) *Astrophys. J. Suppl. Ser.* **39**, 135.