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VERIFICATION OF CEPHEIDS IN OPEN CLUSTERS AND ASSOCIATIONS AS DISTANCE INDICATORS

The Cepheids, members of open clusters and associations, play important role as objects used for distance and absolute magnitude calibrations. Therefore it is interesting to note that four papers dealing with these stars: Fernie and McGonegal (1983, henceforth FM), Caldwell (1983), Stothers (1983) and Cester and Marsi (1984) differ from each other not only in methods of reduction but even in the selection of stars. The list of 29 stars given by FM is presented in Table I with the addition of four Cepheids: GU Nor, SX Vel, Y Sct, and X Cyg. These latter stars were included to the calibration Cepheids by Cester and Marsi but not by FM.

To provide an independent verification of these stars as distance indicators, the moduli $Mod_{FM} = (m-M)_o$ taken from FM paper have been compared with the similar values calculated from the new P—L—C relation for galactic field Cepheids, see Ciurla and Opolski (1984):

$$M_{<V>} = \underset{\pm.81}{5.40}\underset{\pm.84}{<B-V>_o} - \underset{\pm.60}{5.20 \log P} - 3.44 \qquad (1)$$

s.d. = 0.29

Assuming the ratio of total to selective absorption R = 3.20 we have:

$$E_{B-V} = <B-V> - <B-V>_o \qquad (2)$$

$$<V>_o = <V> - 3.20(<B-V> - <B-V>_o) \qquad (3)$$

and $$Mod_0 = <V>_o - M_{<V>}$$

or $$Mod_0 = <V> - 5.40<B-V> + 5.20 \log P + 2.20 E_{B-V} + 3.44 \qquad (4)$$

For the present study the values of <V> and <B - V> have been taken from the catalogue of Schaltenbrand and Tammann (1971) and supplemented for five stars according to the references given by FM. These values are quoted in Table I with two decimal figures. The E_{B-V} values are given according to the papers by Dean et al. (1978) and Pel (1978) after reducing to the Dean's et al. system. In four cases when these quantities were missing, the Dean's et al. (1978) P-C relation has been applied to get $<B-V>_o$ and E_{B-V}. These values are given in brackets. For four additional stars the reddenings E_{B-V}

Table I. Cepheids in open clusters and associations

Star	log P	<V>	<B-V>	E_{B-V}	Mod_0	Mod_{FM}	ΔMod
reliable distance indicators, $\|\Delta Mod\| < 0.45$							
SU Cas	0.290	5.969	0.725	0.24	7.54	7.72	+0.18
EV Sct	.490	10.128	1.157	0.64	11.28	11.15	-0.13
GU Nor	.538	10.406	1.297	0.68	11.14	(11.11)	-0.03
CE Cas b	.651	10.988	1.140	(0.54)	12.85	12.85	0.00
CF Cas	.688	11.110	1.227	0.55	12.72	12.85	+0.13
CE Cas a	.711	10.919	1.213	(0.58)	12.79	12.85	+0.06
UY Per	.730	11.306	1.591	0.91	11.96	12.05	+0.09
CV Mon	.731	10.296	1.369	0.75	11.80	11.50	-0.30
VY Per	.743	11.193	1.644	1.00	11.82	12.05	+0.23
U Sgr	.829	6.714	1.142	0.43	9.25	9.21	-0.04
DL Cas	.903	8.942	1.216	0.51	11.64	11.35	-0.29
S Nor	0.989	6.414	0.969	0.32	10.26	9.95	-0.31
Y Sct	1.015	9.631	1.587	0.75	11.43	(11.28)	-0.15
TW Nor	.033	11.68	2.03	1.20	12.17	11.77	-0.40
VX Per	.037	9.300	1.242	0.49	12.51	12.06	-0.41
X Cyg	.214	6.395	1.213	0.23	10.10	(10.29)	+0.19
VY Car	.278	7.446	1.193	0.24	11.63	11.86	+0.23
RU Sct	.294	9.500	1.779	1.02	12.32	11.89	-0.43
RZ Vel	.310	7.114	1.209	0.32	11.55	11.52	-0.03
WZ Sgr	.339	8.018	1.455	0.43	11.52	11.26	-0.26
SW Vel	.371	8.126	1.252	0.38	12.78	12.38	-0.40
T Mon	.432	6.137	1.252	0.18	10.67	11.10	+0.43
RS Pup	.617	7.006	1.489	0.52	11.97	11.55	-0.42
SV Vul	.654	7.221	1.534	0.41	11.89	12.10	+0.21
GY Sge	.708	10.23	2.25	1.11	12.85	12.99	+0.14
S Vul	1.826	9.00	1.92	0.77	13.27	13.51	+0.24
questionable distance indicators, $\|\Delta Mod\| > 0.60$							
V Cen	0.740	6.818	0.914	0.32	9.88	9.24	-0.64
CS Vel	0.771	11.70	1.37	0.68	13.26	11.95	-1.31
V367 Sct	0.799	11.578	1.700	(1.03)	12.26	11.49	-0.77
SX Vel	0.980	8.263	0.904	0.28	12.53	(11.60)	-0.93
SZ Cas	1.134	9.826	1.505	0.85	12.91	12.05	-0.86
KQ Sco	1.458	9.349	1.980	(0.99)	11.90	12.60	+0.70
V810 Cen	2.115	5.06	0.81	0.26	15.70	12.44	-3.26

according to Cester and Marsi (1984) have been adopted.

Table I contains also the moduli Mod_0 resulting from the formula (4) and FM moduli, Mod_{FM} . For four stars taken additionally from the paper by Cester and Marsi we have assumed as Mod_{FM} the values of $(m-M)_o$ given by these authors increased by 0.30, because there is a systematic difference about 0.30 between the moduli published in these two papers for the 23 common stars. In Table I these Mod_{FM} values are given in brackets.

The differences $\Delta Mod = Mod_{FM} - Mod_0$ are presented in the last column of Table I. From these values the following conclusion may be drawn:

1. In Table I there are 33 Cepheids proposed as distance indicators, but only for 26 ones, listed in the upper part of the Table the values $|\Delta Mod|$

are smaller than 0.45 . They can be explained as the result of uncertainties in cluster distances and as due to the limited accuracy of formula (4). Therefore these 26 stars should be recommended as reliable distance indicators. These stars determine the P - L relation given by FM and discussed by Ciurla and Opolski (1984).

2. The remaining seven stars in the lower part of Table I have $|\Delta Mod|$ greater than 0.6 , which makes them questionable as distance indicators. Two of them, CS Vel and V 810 Cen, have been already omitted by FM in the investigation of the P - L relation. V Cen has been rejected by Stothers (1983) and SZ Cas by Caldwell (1983). The double mode Cepheid, V 367 Sct, has been discussed a number of times with conflicting conclusions. Also the membership of KQ Sco in the association may be questioned.

3. The distances of U Sgr and V Cen resulting from the moduli Mod_O , Mod_{FM} and Mod_C , the latter from the paper by Caldwell (1983) can be compared with the distances published recently by Gieren (1984). His values were obtained by the surface brightness method:

	distances in pc	
	U Sgr	V Cen
from Mod_O	709	947
from Mod_{FM}	695	705
from Mod_C	673	689
Gieren	709	897

The consistency in the distance of U Sgr is confirmed in contrast with the differences in V Cen data, in accordance with the foregoing suggestion that the latter star belongs to the questionable distance indicators.

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