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The optical gravitational lensing experiment. Variable stars in globular clusters

III. RR Lyrae stars and Pop. II Cepheids in ω Centauri*

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Abstract. We present V-band photometry for 141 variable stars from the field of ω Cen. All but one variables are either RR Lyr stars or Pop. II Cepheids. One object is a distant background RR Lyr star from the galactic halo. The presented sample includes 33 newly identified variables, mostly low amplitude RR Lyr stars. We identified also two Pop. II Cepheids with exceptionally low amplitudes of light variations $A_V < 0.2$ mag. The presented data may be used to study period changes of ω Cen variables and/or for Fourier decomposition of light curves[1].

Key words: globular clusters: individual: NGC 5139 — stars: variables: RR Lyr — stars: variables: other

1. Introduction

The Optical Gravitational Lensing Experiment (OGLE) is a long term project with the main goal of searching for dark matter in our Galaxy by identifying microlensing events toward the galactic bulge (Udalski et al. 1992, 1994). At times the Bulge is unobservable we conduct other long-term photometric programs. A complete list of side-projects attempted by the OGLE team can be found in Paczyński et al. (1995). In particular, we monitored globular clusters NGC 104 (=47 Tuc) and NGC 5139 (=ω Cen) in a search for variable stars of various types. In Papers I & II (Kaluzny et al. 1996; Kaluzny et al. 1997) we reported on 70 variables from the field of ω Cen. That sample consisted mostly of eclipsing binaries and SX Phe stars. In this contribution we provide light curves for other 141 variables in ω Cen. The present sample consists mostly of RR Lyr stars. A few variables located outside horizontal branch of the cluster are also included.

Omega Centauri is known to possess a very rich population of RR Lyr stars which were first studied by Bailey (1902) and, more extensively, in a landmark paper by Martin (1938). Some recent contributions on RR Lyr stars in ω Cen are those by Gratton et al. (1986) and Dickens (1989). A more complete bibliography on the subject can be found in Smith (1995).

2. Observations and data reduction

The OGLE[2] project was conducted using the 1-m Swope telescope at Las Campanas Observatory. A single 2048 × 2048 pixels Loral CCD chip, giving the scale of 0.435 arcsec/pixel was used as the detector. The initial processing of the raw frames was done automatically in near-real time. Details of the standard OGLE processing techniques were described by Udalski et al. (1992).

This paper is based on the data obtained during 1993-5 observing seasons. The cluster was monitored each season for a period spanning about 3 months. Detailed logs of observations can be found in Udalski et al. (1995, 1996). Seven different fields covering a central part of the cluster

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* Based on observations collected at the Las Campanas Observatory of the Carnegie Institution of Washington.

[1] Tables 3-200 are available in electronic form only at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

[2] The OGLE project is currently conducted, under the name OGLE-2, using a dedicated 1.3-m telescope located at Las Campanas Observatory.

Table 1. Light curve parameters and rectangular coordinates for ω Cen variables OGLEGC71-211

ID OGLEGC	Field	P day	V mean	A_V	V max	X pix	Y pix	ID OGLEGC	Field	P day	V mean	A_V	V max	X pix	Y pix
71	A	0.3330	14.56	0.17	14.47	126.1	222.2	118	B	0.6768	14.35	0.71	13.98	872.4	1187.5
72	A	1.3461	13.98	0.35	13.84	382.8	276.2	119	B	0.3342	14.53	0.46	14.32	733.8	1269.6
73	A	0.5346	14.26	0.39	14.06	353.2	506.6	120	B	0.7846	14.50	0.59	14.19	550.6	1295.2
74	A	0.7729	14.44	0.65	14.10	611.7	597.1	121	B	0.3159	14.46	0.25	14.35	940.2	1319.4
75	A	0.4932	14.74	0.67	14.40	352.2	1329.1	122	BC	0.8128	14.56	0.49	14.31	867.6	1464.3
76	A	0.4075	14.64	0.42	14.45	793.9	80.5	122	B	0.8131	14.44	0.48	14.18	827.0	1385.7
76	B	0.4075	14.55	0.45	14.35	819.4	1907.1	123	B	1.0253	13.54	0.27	13.47	746.0	1427.7
76	BC	0.4074	14.55	0.40	14.36	863.7	1985.4	124	B	0.8106	14.38	0.72	14.02	656.8	1613.4
77	A	0.5644	14.72	1.00	14.15	729.9	589.8	124	BC	0.8107	14.43	0.72	14.06	699.2	1692.7
78	B	0.3868	14.54	0.49	14.32	1288.7	1848.0	125	B	0.3868	14.52	0.45	14.31	664.7	1686.1
78	A	0.3868	14.57	0.47	14.35	1263.5	21.5	125	BC	0.3867	14.56	0.44	14.35	707.6	1765.4
79	A	0.3380	14.54	0.39	14.36	1384.4	351.1	126	BC	0.5643	14.56	0.75	14.11	798.8	1907.0
80	BC	0.4259	14.57	0.37	14.41	1981.7	1933.3	126	B	0.5647	14.53	0.75	14.16	755.0	1828.4
80	B	0.4264	14.53	0.42	14.33	1937.6	1862.4	127	B	0.7200	14.27	0.54	13.93	814.2	1118.7
80	A	0.4263	14.57	0.43	14.38	1912.2	35.1	128	B	0.5733	14.60	1.20	13.88	1257.5	573.9
80	E	0.4262	14.57	0.43	14.38	108.0	2001.2	129	BC	0.6630	14.48	0.88	13.93	1419.7	744.3
81	A	0.2496	14.61	0.11	14.55	1791.7	128.4	129	B	0.6630	14.52	0.83	13.98	1384.2	669.5
82	A	0.6204	14.54	1.17	13.86	1508.9	130.1	130	B	0.3732	14.56	0.44	14.36	1146.8	672.9
83	A	0.3566	14.60	0.49	14.38	1628.3	131.4	130	BC	0.3732	14.55	0.49	14.30	1182.3	749.3
84	A	0.4221	14.50	0.39	14.33	1922.1	494.0	131	B	0.2381	14.61	0.23	14.50	1282.0	806.9
85	A	0.5032	14.62	1.22	13.87	1645.6	684.4	132	BC	0.4432	14.40	0.43	14.19	1099.7	905.6
86	A	0.3798	14.55	0.49	14.32	1737.5	965.3	132	B	0.4431	14.44	0.43	14.23	1063.0	828.7
87	A	0.7130	14.59	0.93	14.08	1540.0	1187.7	133	B	0.7439	14.45	0.92	13.99	1403.5	864.4
88	BC	0.5675	14.78	0.98	14.21	472.4	332.7	134	B	0.3115	14.63	0.19	14.53	1011.0	1404.3
88	B	0.5675	14.72	0.99	14.16	439.6	251.3	135	B	0.3673	14.59	0.42	14.40	1014.9	749.2
89	BC	0.6304	14.56	1.16	13.88	241.5	393.2	136	B	0.7631	14.46	0.60	14.15	1122.6	1017.3
89	B	0.6305	14.53	1.03	13.94	208.2	310.4	136	BC	0.7628	14.45	0.63	14.13	1160.5	1093.8
90	D	0.7340	14.52	0.77	14.10	2006.9	322.1	137	BC	0.7662	14.26	1.11	13.64	1476.2	1184.7
90	B	0.7340	14.47	0.79	14.05	101.8	473.6	137	B	0.7660	14.33	1.08	13.75	1437.6	1110.3
90	BC	0.7340	14.49	0.80	14.06	136.4	557.1	138	B	0.4066	14.56	0.45	14.35	1078.8	1212.1
91	B	0.8350	14.32	0.59	14.02	378.8	861.6	139	B	0.3672	14.60	0.39	14.42	1263.5	1217.4
92	BC	0.4038	14.52	0.46	14.30	377.3	985.7	140	B	0.3863	14.55	0.44	14.35	1163.0	1329.6
92	B	0.4040	14.45	0.42	14.26	339.9	903.9	140	BC	0.3863	14.55	0.46	14.32	1203.2	1405.7
93	BC	0.5184	14.80	1.05	14.18	437.0	1002.0	141	B	0.6034	14.53	1.04	13.92	1071.6	1337.6
93	B	0.5186	14.72	0.64	14.35	399.5	920.6	142	B	0.3414	14.54	0.13	14.49	1079.0	1355.7
94	BC	0.4215	14.53	0.43	14.33	476.4	1057.9	142	BC	0.3405	14.55	0.25	14.43	1119.4	1432.4
94	B	0.4216	14.46	0.45	14.25	438.5	976.9	143	BC	0.3749	14.56	0.47	14.34	1121.8	1465.3
95	B	0.4881	15.11	0.10	15.07	154.6	834.8	143	B	0.3748	14.57	0.46	14.35	1081.1	1388.6
96	B	0.5028	14.28	0.17	14.19	315.2	1428.3	144	BC	0.3965	14.61	0.49	14.39	1394.6	1500.4
96	BC	0.5024	14.35	0.24	14.24	356.4	1510.0	144	B	0.3965	14.58	0.46	14.38	1353.7	1425.5
97	BC	0.3808	14.43	0.46	14.20	313.0	1538.9	145	B	0.4139	14.46	0.42	14.27	1274.3	1554.0
97	B	0.3808	14.38	0.50	14.13	271.6	1457.0	145	BC	0.4139	14.54	0.40	14.36	1316.2	1629.4
98	BC	0.3748	14.54	0.44	14.35	232.1	1735.8	146	B	0.5109	14.80	1.02	14.19	1108.2	1574.7
98	B	0.3751	14.45	0.40	14.28	189.3	1653.5	146	BC	0.5109	14.86	1.04	14.23	1150.2	1651.1
99	BC	0.6273	14.52	1.06	13.90	373.5	1764.8	147	B	0.5741	14.50	1.17	13.80	1020.9	1623.2
99	B	0.6273	14.43	1.09	13.81	330.6	1683.4	147	BC	0.5742	14.56	1.18	13.84	1063.2	1700.2
100	BC	0.3699	14.52	0.20	14.42	379.3	1800.7	148	B	0.3111	14.60	0.23	14.49	1064.4	1835.1
100	B	0.3699	14.44	0.29	14.30	336.1	1719.4	148	BC	0.3111	14.63	0.24	14.51	1108.3	1911.8
101	B	0.5154	14.67	1.25	13.91	468.1	1825.9	149	B	0.6087	14.50	0.34	14.32	1151.0	1160.7
102	B	0.6349	14.52	1.07	13.91	640.5	450.7	150	B	0.4743	14.60	1.12	13.89	1225.5	771.2
103	B	1.3496	13.63	0.99	13.17	768.1	473.3	151	B	0.3906	14.51	0.42	14.32	1966.5	249.7
104	B	0.5486	14.73	0.73	14.37	531.7	490.4	151	E	0.3906	14.55	0.42	14.35	154.1	389.5
104	BC	0.5486	14.75	1.04	14.17	566.1	571.0	151	BC	0.3908	14.57	0.41	14.38	1999.2	320.7
105	B	0.3042	14.58	0.28	14.44	603.7	618.9	152	B	0.3078	14.55	0.22	14.44	1709.7	328.8
106	BC	0.3059	14.67	0.30	14.53	880.2	753.6	152	BC	0.3078	14.59	0.24	14.48	1742.9	401.6
106	B	0.3059	14.65	0.29	14.50	844.6	675.2	153	E	0.6914	14.55	0.94	14.03	57.1	881.7
107	BC	0.6340	14.55	1.12	13.90	567.8	853.6	153	B	0.6914	14.53	0.93	14.01	1874.5	743.2
107	B	0.6341	14.50	1.10	13.86	531.4	773.1	153	BC	0.6914	14.56	0.92	14.05	1910.6	814.8
108	B	0.3214	14.75	0.45	14.53	885.3	786.9	154	BC	0.5141	14.84	1.17	14.13	1714.0	727.0
109	B	0.6116	14.43	1.00	13.82	907.8	806.2	154	B	0.5141	14.80	1.12	14.14	1678.6	654.0
110	B	0.3920	14.48	0.41	14.29	671.0	913.4	155	B	0.3517	14.59	0.15	14.53	1390.4	1159.6
110	BC	0.3922	14.52	0.41	14.33	708.3	992.9	156	B	1.0066	13.32	0.16	13.24	1509.7	1192.5
111	B	0.4229	14.46	0.37	14.30	684.7	1040.4	157	BC	0.3574	14.59	0.52	14.35	1613.1	1166.1
111	BC	0.4229	14.47	0.30	14.33	722.9	1119.7	157	B	0.3574	14.57	0.52	14.32	1574.6	1092.6
112	B	0.8352	14.41	0.48	14.17	987.9	1080.0	158	B	0.6478	14.54	1.04	13.94	1758.9	1309.8
113	B	0.5885	14.50	0.94	13.94	579.4	1099.3	158	BC	0.6479	14.54	1.02	13.96	1799.1	1382.0
114	B	0.6157	14.73	0.58	14.42	592.6	1113.8	159	B	0.6919	14.53	0.94	14.01	1610.8	1414.7
114	BC	0.6157	14.77	0.62	14.44	631.4	1193.7	159	BC	0.6919	14.52	0.94	14.00	1651.7	1487.9
115	B	0.3524	14.54	0.27	14.40	911.4	1123.2	160	B	0.2806	14.84	0.51	14.59	1533.3	1223.0
116	B	0.6604	13.95	0.44	13.66	807.5	1126.5	161	B	0.9707	13.85	0.11	13.77	1623.9	1157.9
117	B	0.6199	14.48	0.98	13.95	609.4	1161.3	162	BC	0.2681	14.76	0.11	14.70	1700.9	1819.1
117	BC	0.6198	14.47	1.12	13.81	648.5	1241.1	162	B	0.2817	14.71	0.18	14.62	1657.6	1746.3

Table 1. continued

ID OGLEGC	Field	P day	V mean	A_V	V max	X pix	Y pix	ID OGLEGC	Field	P day	V mean	A_V	V max	X pix	Y pix
163	BC	0.6155	14.57	1.08	13.94	1749.1	1120.2	189	E	0.4623	14.48	0.38	14.30	394.4	299.2
163	B	0.6156	14.54	1.10	13.93	1710.8	1047.6	190	E	0.3960	14.56	0.43	14.36	458.7	310.6
164	B	2.2743	13.65	0.57	13.41	1716.0	1129.9	190	F	0.3959	14.58	0.45	14.38	580.9	1977.5
165	C	0.6046	14.69	0.96	14.10	45.5	1671.8	191	E	0.3034	14.65	0.22	14.54	192.2	680.3
166	C	0.5929	14.58	1.17	13.90	967.7	1165.6	192	E	0.2996	14.86	0.46	14.64	264.8	1160.3
167	C	0.2850	14.63	0.07	14.60	1300.4	263.0	193	E	0.3358	14.59	0.42	14.38	407.4	1369.0
168	C	0.3319	14.63	0.49	14.39	1114.2	1421.7	194	E	0.3410	14.85	0.47	14.64	249.7	917.1
169	C	0.4743	14.46	0.41	14.25	1058.4	1690.1	195	E	0.3894	14.57	0.43	14.36	448.9	1601.4
170	C	0.7791	14.51	0.60	14.21	1348.2	1765.8	196	BC	0.3191	14.64	0.23	14.53	1949.0	1673.9
171	C	0.5005	15.24	0.09	15.20	1781.5	202.2	196	B	0.3191	14.59	0.23	14.48	1906.6	1602.7
172	F	0.5174	18.10	1.08	17.44	338.8	260.8	196	E	0.3191	14.64	0.22	14.53	79.9	1741.3
172	C	0.5173	18.13	1.01	17.47	2005.1	304.6	197	F	0.3934	14.58	0.45	14.37	1010.1	1864.1
173	D	3.3207	18.56	0.40	18.36	383.8	34.2	197	E	0.3934	14.57	0.44	14.36	888.7	200.5
174	D	0.5799	14.27	0.66	13.91	188.3	904.7	198	E	0.3353	14.73	0.46	14.52	588.4	494.6
175	D	0.3053	14.63	0.32	14.48	943.9	1031.8	199	E	0.5213	14.67	1.21	13.92	688.0	1095.5
176	D	0.7427	14.47	0.74	14.07	696.2	1750.7	200	E	0.6217	14.54	1.10	13.89	643.6	1568.6
177	D	0.3290	14.58	0.19	14.49	1361.2	145.2	201	E	0.8666	14.49	0.35	14.33	1083.7	319.1
178	D	0.4050	14.56	0.44	14.36	1068.4	987.2	201	F	0.8660	14.51	0.37	14.33	1206.0	1981.2
179	D	0.5891	14.55	1.16	13.83	1222.4	1188.2	202	E	0.2954	14.64	0.10	14.60	1245.2	1684.8
180	D	0.6870	14.52	0.93	14.00	1223.0	1394.0	203	E	0.3080	14.64	0.24	14.52	1109.5	2016.9
181	D	0.3213	15.17	0.44	14.96	1682.6	502.6	204	E	0.6083	14.60	1.08	13.98	1529.1	885.9
182	D	0.6023	14.55	1.12	13.88	1686.2	911.2	205	F	0.3302	14.56	0.50	14.32	465.6	1508.7
183	D	0.5234	14.81	0.72	14.39	1900.3	1268.4	206	F	0.7946	14.47	0.56	14.17	745.3	1589.0
183	BC	0.5235	14.81	0.77	14.35	38.7	1504.1	207	F	0.3420	14.60	0.46	14.39	1135.2	1013.6
184	D	0.8413	14.41	0.77	14.03	1825.7	1343.7	208	BC	0.4969	14.72	0.10	14.66	150.7	1485.3
185	D	0.4851	14.35	0.42	14.15	1851.0	1576.8	209	BC	0.3342	14.61	0.14	14.52	860.0	455.1
186	D	0.2539	14.80	0.27	14.66	1880.0	1773.0	210	BC	0.6904	14.23	0.67	13.85	1362.3	1547.2
187	D	0.3862	14.66	0.45	14.46	1756.4	1113.5	211	BC	0.5945	14.62	1.05	14.00	1515.6	957.6
188	D	0.6691	14.51	0.97	13.96	1878.6	1414.0								

were observed. In 1993 we monitored fields 5139A, 5139B and 5139C. Field 5139BC, which was monitored in 1994, covered approximately the same part of the cluster as field 5139B. Both fields, 5139B and 5139BC, covered the most central part of the cluster. For field 5139BC we used exposure times by a factor of 2 longer than exposure times used in case of field 5139B. In 1995 season we monitored fields 5139D, 5139E and 5139F. The exact coordinates and location of all seven fields are given in Papers I and II. Most of monitoring was performed through the Johnson V filter. Some exposures in the Kron-Cousins I band were also obtained. However, the existing material does not allow to determine average I-band magnitudes for most of the variables. Therefore we limited our discussion to the V-band data.

The reduction techniques as well as algorithms used for selecting periodic variables are described in Paper I. The profile photometry was extracted with the help of DoPHOT (Schechter et al. 1993).

3. Light curves and photometric properties of variables

In Table 1 we list some basic information for these variables indentified in fields 5139A-F which were not discussed in Papers I or II. The OGLEGC ID numbers assigned to variables are continuation of the sequence from Papers I and II. Some fraction of variables was observed in more than one field. For such stars multiple entries are given in Table 1. Hence, Table 1 lists in fact light curves which were obtained for variables OGLEGC71-211. The field in which a given variable was observed is listed in Cols. 2 and 10. The rectangular coordinates (X, Y) correspond to position of a given variable on a template image for a given field. The list of template images as well as instruction how to retrieve them can be found in Papers I and II. The periods listed in Table 1 were obtained using ANOVA statistics (Schwarzenberg-Czerny 1996). For each light curve we list also the intensity averaged V magnitude, the full amplitude of light variations and the magnitude at maximum light. For stars with multiple entries in Table 1 the values of $V_{\rm mean}$ or $V_{\rm max}$ show field-to-field differences on the level of a few hundredth's of magnitude. These differences reflect mostly some uncertainties of the zero points of the photometry which were introduced by the particular method of reduction. These uncertainties prevented us from combining photometry obtained in different fields for the same variables. For some of variables real and pronounced changes of light curve amplitudes are observed. In fact Martin (1938) was first to note such changes for several RR Lyr stars in ω Cen. Table 2 gives equatorial coordinates for variables OGLEGC71-211. We cross-correlated our list of variables with the Hogg (1973) catalogue. The ID numbers from Hogg are listed in Cols. 2, 6 and 10 of Table 2. For 33 variables we could not find their counterparts in the Hogg catalogue. On the other hand we failed to obtain photometry for several known variables which were present in the monitored fields. The

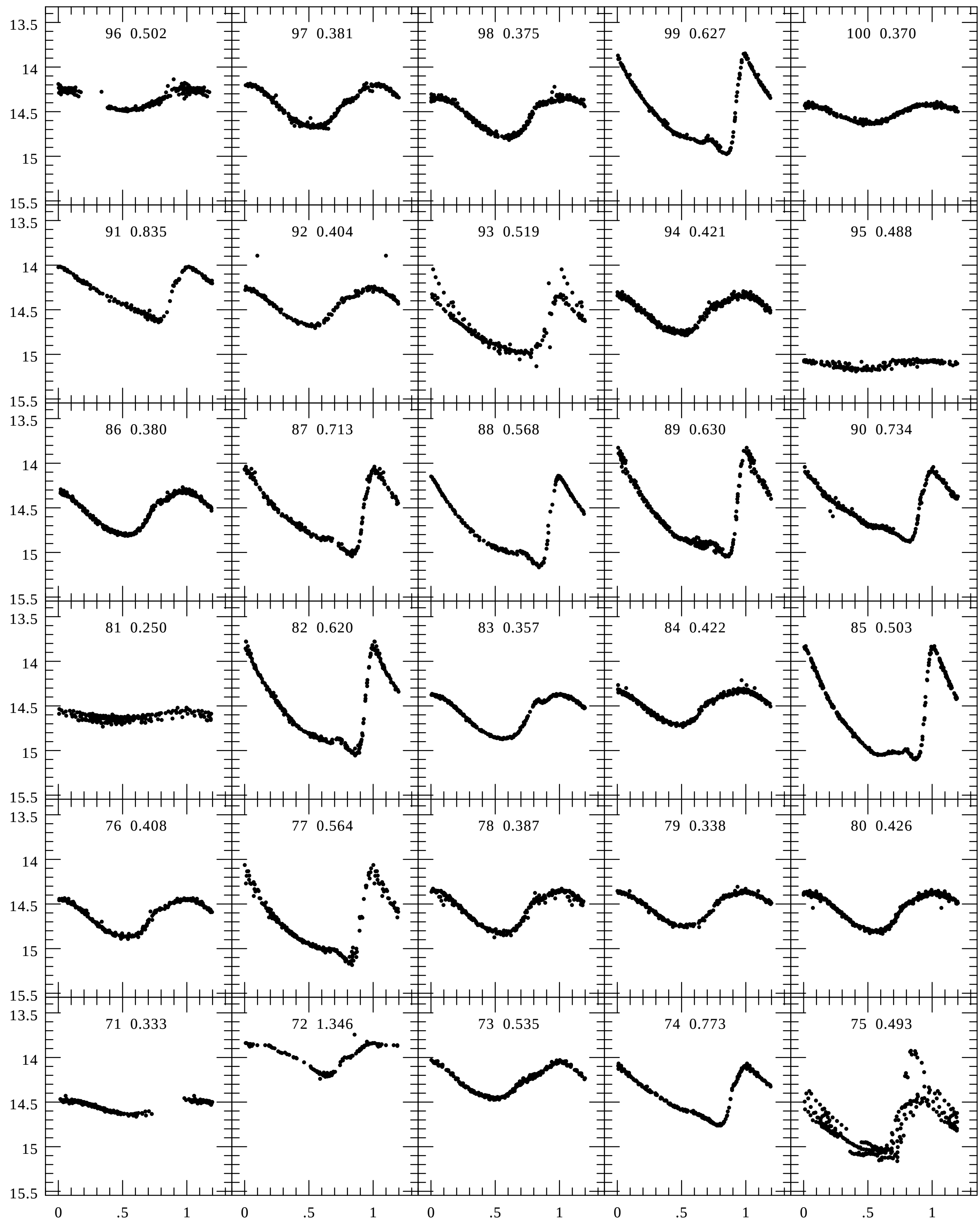

Fig. 1. Phased light curves for bright variables from the field of ω Cen

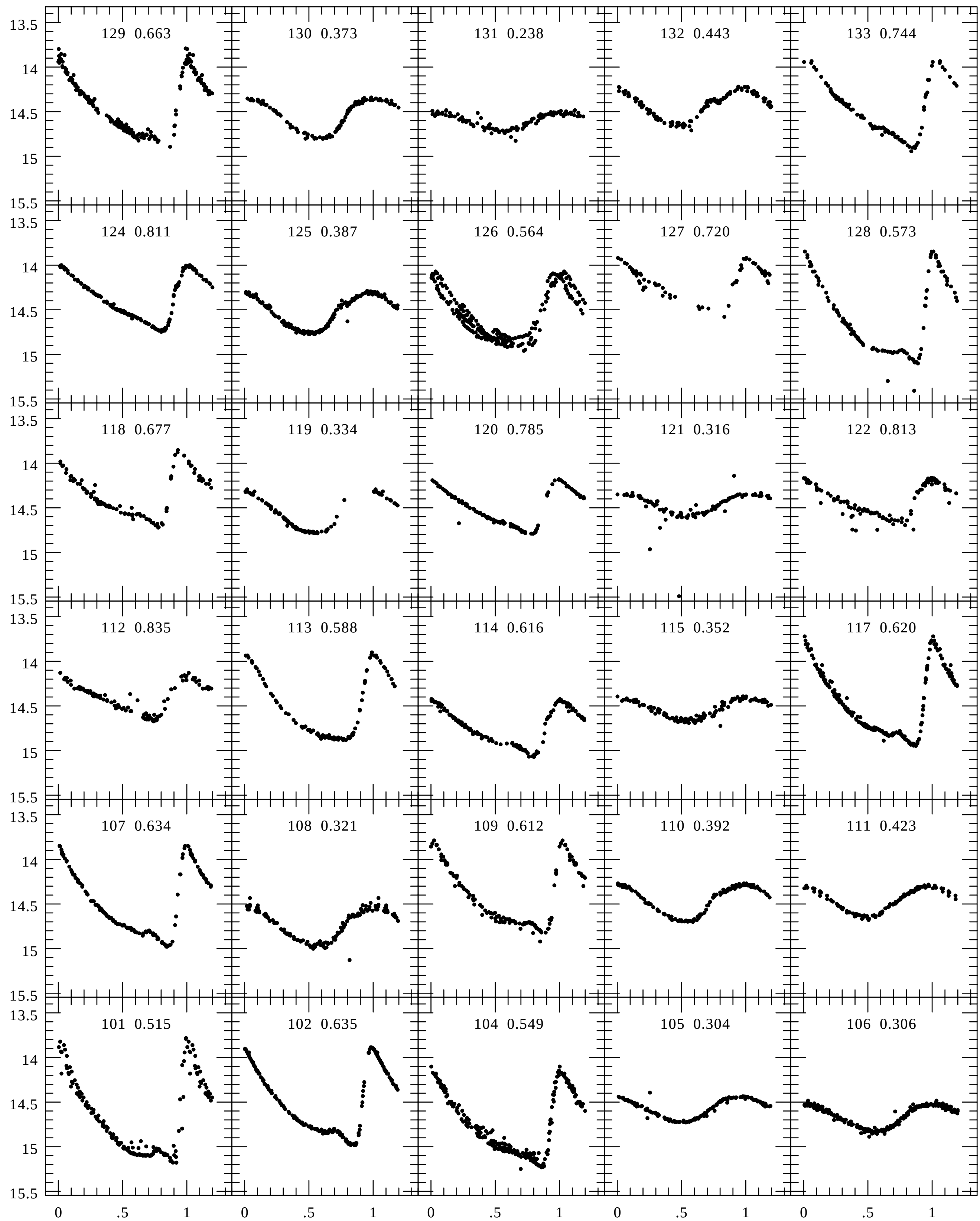

Fig. 1. continued

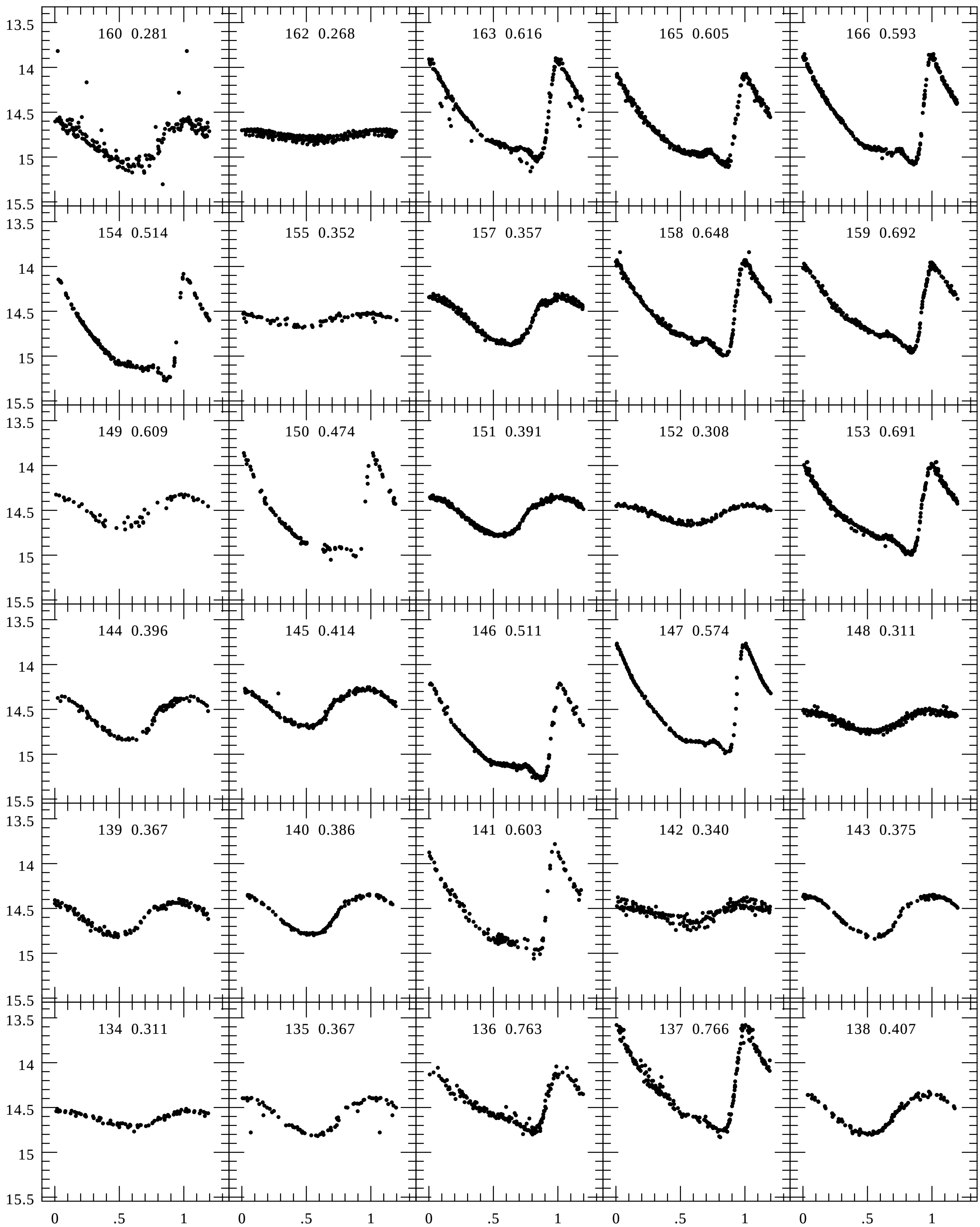

Fig. 1. continued

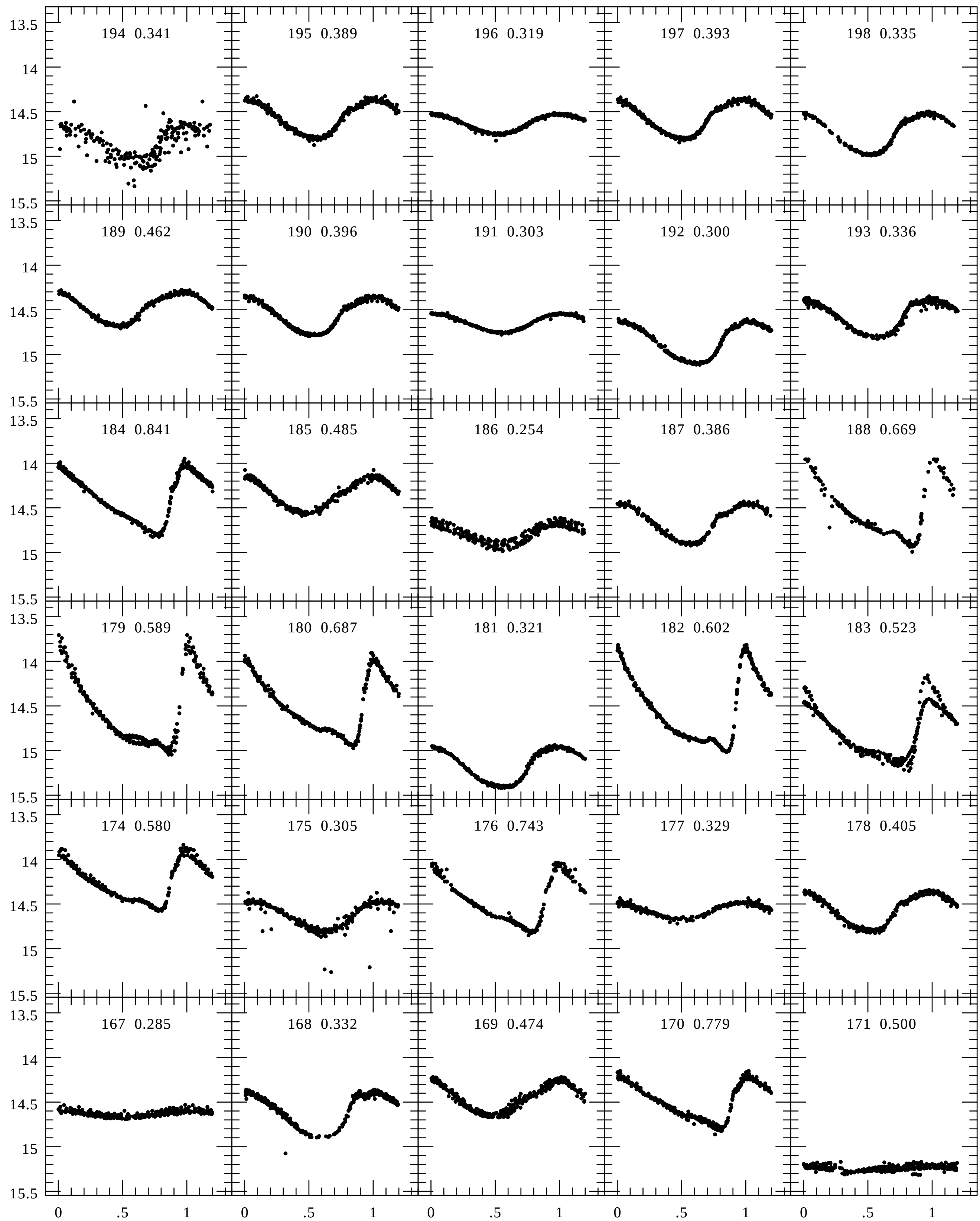

Fig. 1. continued

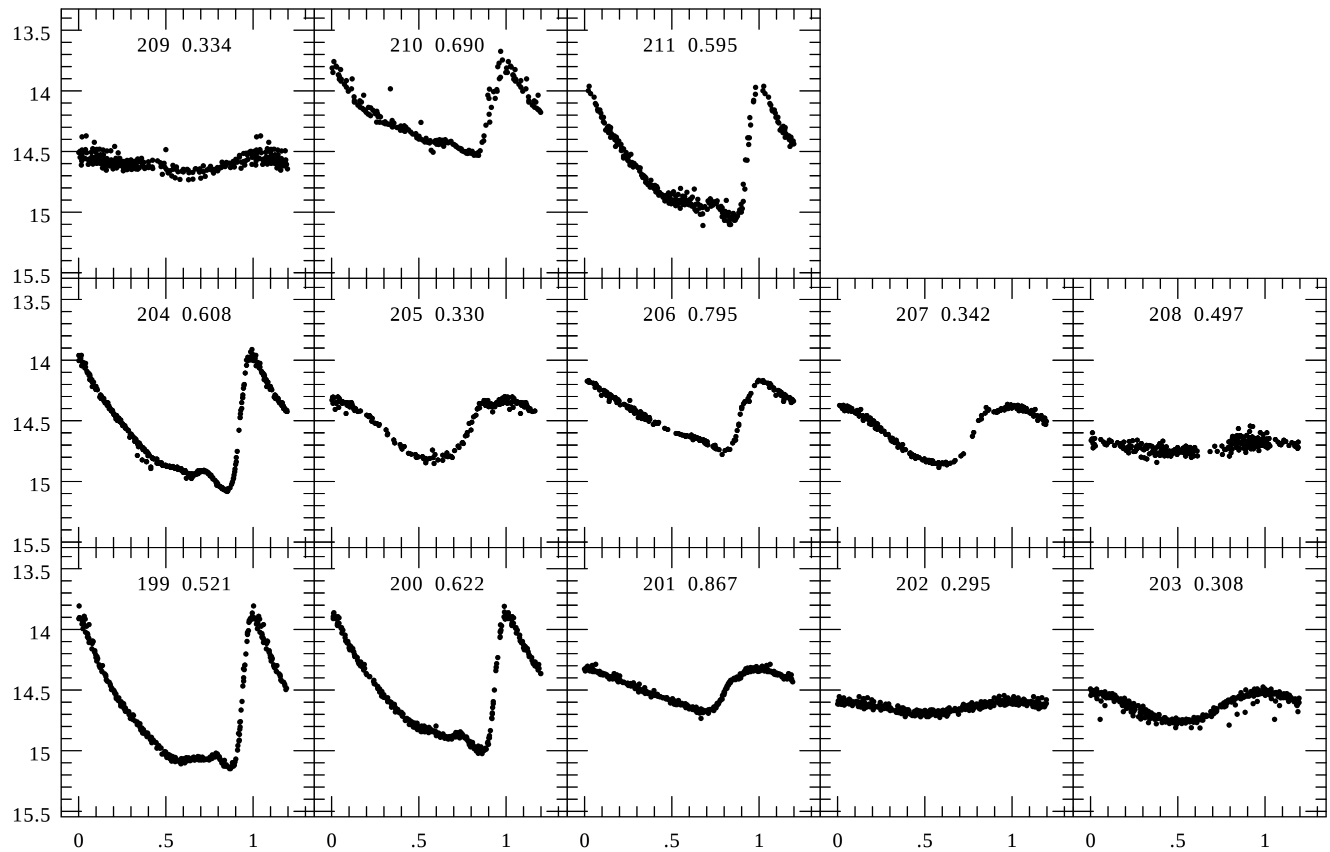

Fig. 1. continued

most common reason for such a failure was a presence of badly saturated stellar images close to images of variables. It has to be noted that our main goal was to look for main sequence binaries. Therefore the duration of exposures was not optimal for photometry of relatively bright variables such as RR Lyr stars or Pop. II Cepheids.

In Fig. 1 we show light curves for variables whose luminosities place them in the H − R diagram on or near the level of the horizontal branch of the cluster. Only one light curve was plotted for each of variables although for many of them more than one light curve was obtained (see Table 1). The well known spread of average magnitudes of ω Cen RR Lyr stars can be easily noted in Fig. 1. No one of RR Lyr stars from our sample showed evidence for being a RRd type variable (RRd stars pulsate simultaneously in the fundamental and in the first overtone mode).

The sample of newly identified variables is dominated by objects with relatively low amplitudes. Moreover a large fraction of these stars have periods close either to 1/2 d or to 1/3 d. The period of OGLEGC162 is uncertain. The power spectrum for the light curve obtained in 1993 (field 5139B) shows peaks for periods 0.44 d, 0.28 d and 0.22 d. The data obtained in 1994 (field 5139BC) are best phased with period 0.268 d. The light curve of this variable is unstable on a time scale of days. Another new low-amplitude variable with unstable light curve is OGLEGC171 for which we adopted $P = 0.500\ d$. The period of this variable is rather firmly established – only one significant peak was detected in the power spectrum.

The light curves for 2 faintest and 6 brightest variables from our sample are plotted in Fig. 2. OGLEGC172 is a background RR Lyr star located well behind the cluster. The nature of OGLEGC173 is less certain. The color of this faint variable is rather red. With $V - I = 1.50$ it is located about 0.5 mag to the red of upper main-sequence of the cluster in the H − R diagram. The variable was first erroneously classified as a field RR Lyr star with a period of about 0.77 day and therefore it was not included in Paper II with other faint variables from field 5139D. The actual period of variability of OGLEGC173 is either 3.32 days or 6.64 days. The possible classes of variables to which OGLEGC173 may belong include the so called "spotted variables" and ellipsoidal variables. The phased light curve presented in Fig. 2 shows a bump near $\phi = 0.65$. This feature corresponds to a flare-like event which occurred on JD $\approx$ 2449827.5. The data from that particular night were discarded while determining a period of the variable. Further observations are needed to solve questions about a nature and membership status of OGLEGC173.

Six bright stars whose light curves are plotted in Fig. 2 have average magnitudes placing them above horizontal branch of ω Cen. Variables V60 = OGLEGC103 and

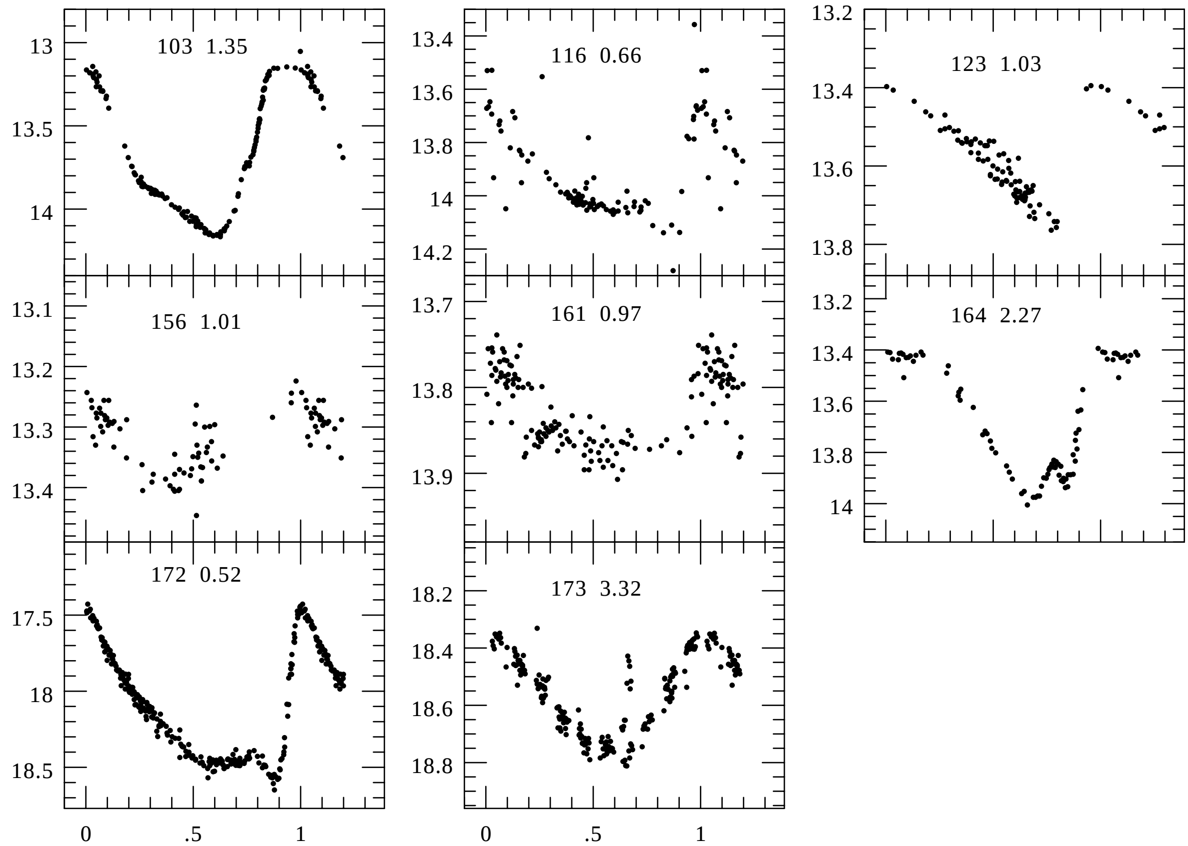

Fig. 2. Phased light curves for 6 brightest and 2 faintest variables from the present sample

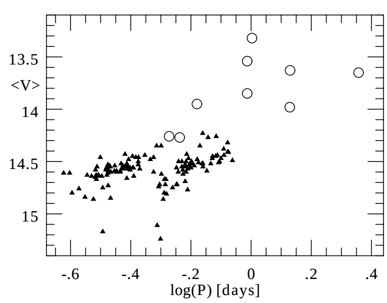

Fig. 3. Period versus average V magnitude for bright pulsating variables observed by OGLE in ω Cen. Objects classified as BL Her stars or anomalous Cepheids are marked with open circles

V61 = OGLEGC164 are classified as Pop. II Cepheids of BL Her subtype (eg. Nemec et al. 1994). V52 = OGLEGC116 has a period $P = 0.66$ day. That value is a bit shorter than the 0.75 day short period limit adopted for Pop. II Cepheids (Wallerstein & Cox 1984). However, luminosity of this star is appropriate for BL Her variables. Properties of BL Her type variables were recently discussed in some details by Nemec et al. (1994) and Sandage et al. (1994). Another BL Her star included in our sample is OGLEGC72 = V92. Variables OGLEGC73 = V68 and OGLEGC174 = V84 are classified as anomalous Cepheids (e.g. Nemec et al. 1994). The light curves of OGLEGC72, OGLEGC73 and OGLEGC174 are presented in Fig. 1. Bright variables OGLEGC123, OGLEGC156 and OGLEGC161 are new discoveries. For all these stars our data indicate periods very close to 1 day which may explain why they were undetected in the previous surveys. Moreover, OGLEGC156 and OGLEGC161 show variations with full amplitudes not exceeding 0.2 mag in the V-band. We consider periods determined for these variables as preliminary. Additional data are needed to settle this problem with confidence. All 3 new variables belong probably either to BL Her stars or to anomalous Cepheids.

In Fig. 3 we present "period" vs. "average magnitude" diagram for all but 2 faintest stars listed in Table 2.

4. Summary

We presented light curves for 141 variable stars from the field of ω Cen. Of these stars 33 objects are new discoveries. Most of the sample consists of cluster RR Lyr stars but it includes also 9 brighter objects which are either BL Her stars or anomalous Cepheids. One background RR Lyr star located far away behind the cluster was discovered. We identified also a faint red variable whose light curve varies with a period $P \approx 3.3$ days.

Table 2. Equatorial coordinates for variables OGLEGC71-211

ID OGLEGC	ID Hogg	α_{2000} deg	δ_{2000} deg	ID OGLEGC	ID Hogg	α_{2000} deg	δ_{2000} deg	ID OGLEGC	ID Hogg	α_{2000} deg	δ_{2000} deg
71	-	201.51720	−47.36250	118	139	201.65717	−47.45976	165	49	201.53207	−47.63214
72	92	201.56204	−47.35367	119	137	201.63132	−47.45121	166	125	201.70382	−47.68437
73	68	201.55338	−47.32640	120	26	201.59838	−47.44988	167	-	201.77620	−47.78975
74	54	201.59794	−47.31316	121	-	201.66737	−47.44325	168	124	201.72642	−47.65212
75	130	201.54138	−47.22778	122	-	201.64628	−47.43636	169	123	201.71274	−47.62034
76	66	201.63813	−47.37321	123	-	201.63128	−47.43209	170	38	201.76341	−47.60842
77	67	201.61904	−47.31292	124	15	201.61282	−47.41060	171	-	201.86329	−47.79232
78	35	201.72260	−47.37582	125	12	201.61321	−47.40177	172	-	201.90180	−47.77778
79	76	201.73895	−47.33528	126	11	201.62727	−47.38380	173	-	201.24356	−47.60229
80	77	201.83780	−47.36797	127	116	201.64777	−47.46860	174	84	201.19769	−47.49903
81	-	201.81487	−47.35799	128	113	201.73459	−47.52990	175	127	201.33068	−47.47712
82	32	201.76454	−47.36050	129	41	201.75577	−47.51718	176	85	201.27703	−47.39277
83	83	201.78576	−47.35921	130	145	201.71342	−47.51906	177	-	201.41680	−47.58013
84	75	201.83222	−47.31300	131	-	201.73556	−47.50163	178	95	201.35352	−47.48137
85	74	201.78016	−47.29286	132	-	201.69624	−47.50111	179	45	201.37848	−47.45578
86	36	201.79213	−47.25829	133	109	201.75638	−47.49353	180	46	201.37591	−47.43101
87	7	201.75377	−47.23348	134	-	201.67875	−47.43236	181	168	201.46996	−47.53410
88	44	201.59329	−47.57653	135	158	201.68880	−47.51114	182	33	201.46532	−47.48486
89	115	201.55115	−47.57161	136	111	201.70414	−47.47784	183	9	201.49921	−47.43988
90	34	201.52988	−47.55298	137	99	201.75887	−47.46361	184	3	201.48478	−47.43152
91	128	201.57385	−47.50368	138	157	201.69355	−47.45483	185	47	201.48627	−47.40324
92	30	201.56631	−47.49896	139	-	201.72635	−47.45242	186	-	201.48890	−47.37939
93	59	201.57670	−47.49638	140	153	201.70686	−47.43988	187	50	201.47532	−47.45986
94	117	201.58286	−47.48924	141	90	201.69048	−47.43980	188	13	201.49339	−47.42256
95	-	201.53425	−47.50902	142	166	201.69154	−47.43755	189	24	201.90982	−47.57093
96	-	201.55463	−47.43610	143	89	201.69145	−47.43357	190	22	201.92110	−47.56900
97	21	201.54647	−47.43307	144	87	201.73941	−47.42650	191	-	201.86920	−47.52673
98	10	201.52913	−47.41021	145	155	201.72345	−47.41182	192	19	201.87601	−47.46823
99	4	201.55384	−47.40527	146	23	201.69363	−47.41093	193	82	201.89860	−47.44185
100	58	201.55432	−47.40089	147	51	201.67741	−47.40594	194	101	201.87641	−47.49769
101	5	201.57633	−47.38683	148	-	201.68216	−47.38002	195	81	201.90295	−47.41346
102	122	201.62631	−47.55063	149	-	201.70715	−47.46032	196	-	201.83594	−47.39968
103	60	201.64876	−47.54670	150	112	201.72602	−47.50647	197	39	201.99892	−47.57849
104	120	201.60633	−47.54689	151	70	201.86581	−47.56204	198	105	201.94182	−47.54570
105	121	201.61735	−47.53075	152	-	201.81882	−47.55502	199	8	201.95184	−47.47243
106	119	201.65951	−47.52168	153	102	201.84206	−47.50355	200	18	201.93784	−47.41577
107	40	201.60228	−47.51287	154	107	201.80847	−47.51618	201	104	202.03213	−47.56249
108	-	201.66516	−47.50784	155	-	201.74977	−47.45815	202	-	202.04299	−47.39660
109	118	201.66890	−47.50531	156	-	201.77052	−47.45302	203	-	202.01447	−47.35774
110	131	201.62518	−47.49467	157	71	201.78352	−47.46442	204	79	202.10412	−47.49034
111	-	201.62582	−47.47926	158	86	201.81315	−47.43650	205	16	201.90671	−47.62649
112	144	201.67926	−47.47160	159	97	201.78529	−47.42532	206	57	201.95551	−47.61414
113	25	201.60624	−47.47318	160	98	201.77429	−47.44913	207	126	202.03345	−47.67964
114	27	201.60839	−47.47131	161	-	201.79136	−47.45609	208	-	201.51848	−47.44119
115	-	201.66501	−47.46714	162	-	201.78882	−47.38497	209	-	201.66053	−47.55779
116	52	201.64648	−47.46773	163	20	201.80842	−47.46851	210	88	201.73296	−47.42120
117	62	201.61070	−47.46543	164	61	201.80816	−47.45855	211	108	201.76947	−47.49050

The nature and membership status of that star require further study. Large fraction of newly discovered cluster RR Lyr stars are variables with relatively low amplitudes of light variations. Also 2 out of 3 newly identified Pop. II Cepheids show light variations with full amplitude not exceeding 0.2 magnitude. We note that none of BL Her stars or anomalous Cepheids listed in an extensive review by Nemec et al. (1994) exhibits such a low amplitude of light variability. Our result suggests that the presently known sample of Pop. II Cepheids is incomplete in respect to low amplitude variables.

Photometric data reported in this paper may be of interest to researchers interested in studying period variability of RR Lyr stars or Pop. II Cepheids. For a significant fraction of presented sample the quality of derived light curves is sufficient to attempt Fourier decomposition.

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5. Appendix A

All light curves listed in Table 1 are published by A&A at the Centre de Données de Strasbourg, where they are available in electronic form: See the Editorial in A&A 1993, Vol. 280, page E1.

References

Bailey S.I., 1902, Harvard Ann. 38
Dickens R.J., 1989, in The Use of Pulsating Stars in Fundamental Problems in Astronomy, Schmidt E.G. (ed.). Cambridge: Cambridge Univ. Press, p. 141
Gratton R.G., Tornambe A., Ortolani S., 1986, A&A 169, 111

Hogg H.S., 1973, Publ. David Dunlap Observ. 6, 1
Kaluzny J., Kubiak M., Szymański M., Udalski A., Krzeminski W., Mateo M., 1996, A&AS 120, 139 (Paper I)
Kaluzny J., Kubiak M., Szymański M., Udalski A., Krzeminski W., Mateo M., Stanek K., 1997, A&AS 122, 471 (Paper II)
Martin W.C., 1938, Ann. Sterrew. Leiden 17, part 2
Nemec J.M., Linnel Nemec A.F., Lutz T.E., 1994, AJ 108, 222
Paczyński B., et al., 1995, IAU Symp. 169: Unsolved Problems of the Milky Way, Blitz L. (ed.), p. 133
Sandage A., Diethelm R., Tammann G.A., 1994, A&A 283, 111
Schechter P., Mateo M., Saha A., 1993, PASP 105, 1342
Schwarzenberg-Czerny A., 1996, ApJ 460, L107
Smith H.A., 1995, RR Lyrae Stars. Cambridge: Cambridge Univ. Press
Udalski A., Szymański M., Kaluzny J., Kubiak M., Mateo M., 1992, Acta Astron. 42, 253
Udalski A., Szymański M., Kaluzny J., Kubiak M., Mateo M., Krzemiński W., 1994, ApJ 426, L69
Udalski A., Szymański M., Kaluzny J., Kubiak M., Mateo M., Krzemiński W., 1995, Acta Astron. 45, 237
Udalski A., Szymański M., Kaluzny J., Kubiak M., Mateo M., Krzemiński W., Stanek K., 1996, Acta Astron. (in print)
Wallerstein G., Cox A.N., 1984, PASP 96, 677