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CCD standards for *U* and *I* in the open cluster NGC 7790 *

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Abstract. Photometric U and I standard sequences in field of the open cluster NGC 7790 are presented. The intention is to achieve wide ranges in magnitude and colour making these sequences suitable for calibrating deep CCD photometry. The 84 standard stars extend the BVR sequences of Odewahn et al. (1992) to the near UV and IR, respectively. – This work is part of a common project between the Universitätssternwarte Bonn, Germany, and the Institute of Astronomy of the Bulgarian Academy of Sciences to study binary open star clusters and clusters in the direction of the Galactic anticentre.

Key words: instrumentation: CCD camera – techniques: photometric – astronomical data bases: standard sequences – open clusters: individual: NGC 7790

1. Introduction

1.1. Photometric standard sequences for imaging detectors

Photometric calibration of the two-dimensional CCD detectors has to rest on standard sequences which should fulfil a number of fundamental requirements: The standard stars should cover a wide as possible range in colour and reach to faint magnitudes. The field of view should have the typical dimensions of a CCD field, $5' \times 5'$, say, and the crowding of stellar images should be a minimum. Of course, the internal and external errors of magnitudes and colours should approach the limits of feasibility.

Practically all modern calibrations refer ultimately to the homogeneous photoelectrically observed set of standard stars by A. U. Landolt (1983). The underlying photometric system is often called $UBVRI$ system for simplicity. But it relies on a combination of systems from the northern and southern hemisphere which can be summarized under the names Johnson-Kron-Cousins (for the intricate history, see Landolt 1983).

In 1985 Christian and co-workers published six photoelectric $BVRI$ standard sequences suitable for video camera and CCD calibration. They had selected between 6 and 12 stars in or near 6 clusters (M 92, NGC 2264, NGC 2419, NGC 4147, NGC 7006, and NGC 7790). Seven years later Odewahn et al. (1992, OBH) extended three of the previous sequences (NGC 4147, NGC 7006, and NGC 7790) to fainter limits and to wider ranges in colour by means of CCD observations. But they restricted the photometric bands to B, V, and R.

1.2. Standard stars in the open cluster NGC 7790

In 1995 we started the project "Structure of the Galaxy: evolution and kinematics of open clusters in the anticentre region" which is a common investigation of the Observatory Hoher List of the University of Bonn, Germany, and the Institute of Astronomy of the Bulgarian Academy of Sciences, Sofia. (Details and results of the project will be given later.) For calibration purposes we used several well-known standard sequences in star clusters, e.g. in M 67 (Montgomery et al. 1993), and in M 92 (Majewski et al. 1994), but most of our photometry was calibrated with standard stars in the open cluster NGC 7790.

The coordinates of NGC 7790 are R.A. = $23^h\ 58\overset{m}{.}4$ and Dec. = $+61°13'(2000)$ – Therefore, most of the year it can be observed from northern sky observatories. Being an intermediate-age open cluster, it is suitable for calibration of different types of astronomical objects like clusters and distant galaxies.

The basic sample of our calibration is the list of 10 NGC 7790 stars with magnitudes in $BVRI$ from the work of Christian et al. (1985) which refer to the fundamental standards of Landolt (1983). We added the improved standards from Odewahn et al. (1992, OBH), in total 114 stars, but calibrated only in the BVR bands (see the preceding section). The ranges in magnitudes and colours are, e.g., $13.15 < V < 18.52$, $0.39 < B - V < 1.71$, and $0.25 < V - R < 1.28$. The stars are spread over a field of $5' \times 3\overset{'}{.}5$ to the south-east of the cluster's centre. Our aim was to extend these BVR sequences also to the pass-

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* Based on observations collected at the National Astronomical Observatory Rozhen, Bulgaria

bands U and I for as many stars as possible in OBH's (1992) field.

We note that Schmidt (1986) published Stroemgren photometry of stars in NGC 7790. Recently Stetson (2000) published Landolt calibrated $BVRI$ data for about 240 stars in a field of $6' \times 6'$ centred on NGC 7790 .

1.3. Constructing the U and I standard sequences

Unfortunately, there exist no suitable standard stars for U in NGC 7790. The only available U data come from
– Sandage (1958): 22 stars, most of them with one single observation only,
– Alcalá & Arellano Ferro (1988, AAF): re-observation of 16 stars from Sandage's list with reference to the Landolt standards,
– Pedreros et al. (1984, PMF): photographic observations calibrated by Sandage's U sequence which they had corrected by 0.075 mag due to an apparent offset in the U scale (Sandage's observations are too blue).
The stars of these lists are spread over an area of about $10' \times 10'$ around the centre of the cluster. The dynamical interval of these data – in magnitudes and colours – is not large enough for CCD receivers and improved techniques of data reduction.

From these lists we find 4 AAF stars and 9 PMF stars (from the corrected Sandage sequence) which coincide with BVR standard stars from OBH. We chose these 13 stars as primary standards in the passband U. They are listed in Table 3 with their OBH numbers; the first 4 stars are those from AAF. Note that we did not use star no.

We used the same 13 stars for to construct the standard sequence in the passband I. The first 4 stars (see Table 3) have I magnitudes from the CCD work of Romeo et al. (1989). For the following stars we can refer to the basic sequence of Christian et al. (1985).

2. Observations and data reduction

The basic observational data for NGC 7790 are presented in Table 1. These frames have been taken with the "Photometrics" CCD camera at the 2 m RC telescope of Rozhen observatory. The detector has $1024 \times 1024\,\mathrm{px}^2$, with a pixel size of $24 \times 24\,\mu^2$. The scale is $0\farcs31$/px without binning and $0\farcs62$/px with binning. At the RC focus of the 2m telescope the field of view is $5' \times 5'$. The filter system is close to Johnson's UBV, and Kron/Cousins RI one.

After standard image reduction with MIDAS, profile fitting photometry was carried out with DAOPHOT II (Stetson 1992) running under MIDAS.

3. Methods of calibration

For the final calibration we use an iteration method to improve the internal accuracy of the magnitudes. Photometric transformation coefficients are determined in three steps using the following transformation relations:

$$U_{st} = a_{0U} + a_{1U} \cdot U_{in} + a_{2U} \cdot (U_{in} - B_{in}) \qquad (1)$$

$$I_{st} = a_{0I} + a_{1I} \cdot I_{in} + a_{2I} \cdot (R_{in} - I_{in}) \qquad (2)$$

where M_{st} are the photometricaly calibrated magnitudes and M_{in} are the instrumental ones.
• Step (1): Determine the transformation coefficients using the above discussed 13 stars and compute the First Step Standard Magnitudes (FSSM) for all the objects in the field of interest.
• Step (2): Use an enlarged standard sequence of 25 stars – 12 more stars added to the first 13 primaries with the FSSM (step 1) – and recompute the magnitudes of all stars in the field, in this way getting the Second Step Standard Magnitudes (SSSM).
• Step (3): Repeat step 2 for all stars with the magnitudes for the 12 added "standards" from the SSSM (step 2) and compute the Third Step Standard Magnitudes (TSSM) of all the stars in the field. Controlling the differences between SSSM and FSSM, and TSSM and SSSM, our results after three iterations seemed to be good enough so that no more iteration was needed. The enlarged primary standard sequence of 25 stars gave us higher accuracy because wider intervals of magnitudes and colours were used.

To check our calibration steps by the "classical way", the standard sequence in M 92 (Majewski et al. 1994) was observed in 1998-02-28. After extinction correction of the instrumental magnitudes, we applied the photometric calibration in the form

$$U_{st} = c_U + c'_U \cdot U_{ec} + c''_U \cdot (U_{ec} - B_{ec}) \qquad (3)$$

$$I_{st} = c_I + c'_I \cdot I_{ec} + c''_I \cdot (R_{ec} - I_{ec}) \qquad (4)$$

where M_{st} are the standard magnitudes after photometric calibration and M_{ec} are the extinction corrected instrumental magnitudes.

4. Results

The U and I magnitudes of the primary standard stars are given in Table 3 and denoted U_s and I_s. The standard errors $\sigma(U_s)$ and $\sigma(I_s)$ of the individual magnitudes are also listed. They are the result of the whole process of reduction and calibration. The mean value is $<\sigma>=$ 0.0165 mag in U and $<\sigma>=$ 0.0122 mag in I. The larger

Table 1. Observational data for NGC 7790 from the 2 m RC telescope

date	filter	no. of frames per filter	scale [″/px]	seeing [″]
1998-02-28	U,B,V,R,I	2	0.62	≤ 2
1998-08-23	U,B,V,R,I	4	0.62	1.5 ... 2
1998-08-23	U,B,V,R,I	2	0.31	1.5 ... 2
1998-09-06	U,B,V,R,I	10	0.62	2.5 ... 3

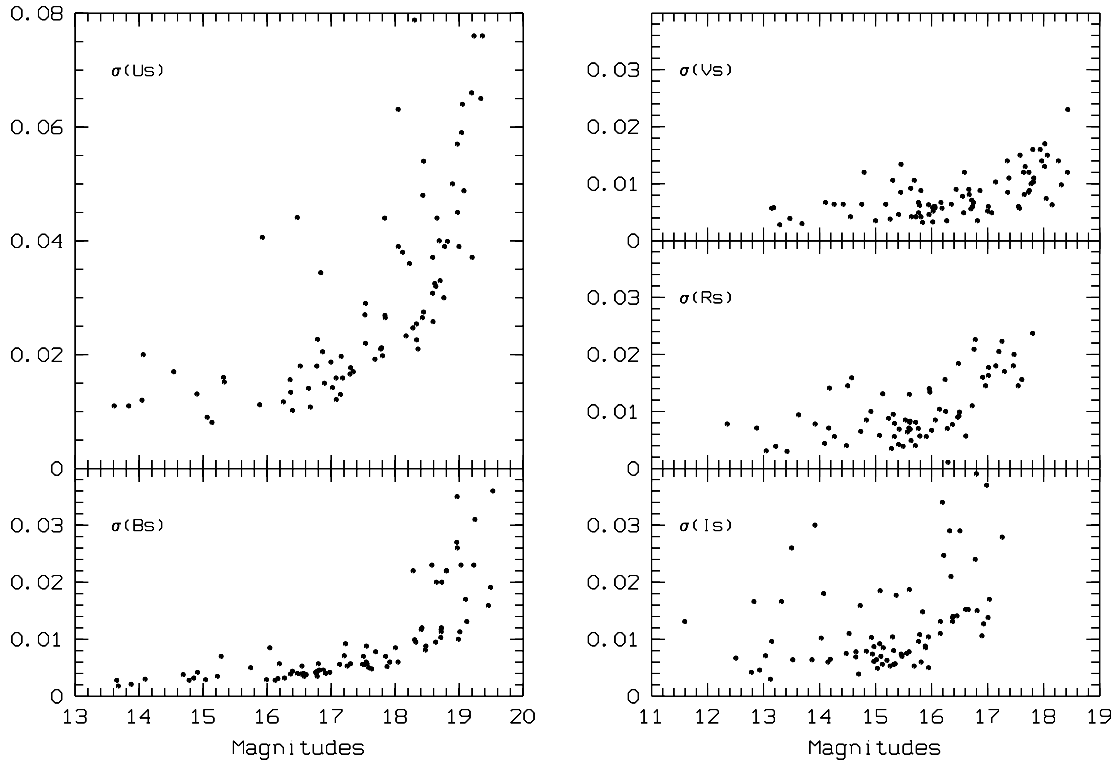

Fig. 1. Estimated errors of the calibration vs. standard star magnitudes

error in U reflects the fact that the CCD receivers are less sensitive in the ultraviolet which means a smaller signal-to-noise-ratio for the observed stars.

The quality of our calibration can be read off columns 6 to 9 of Table 3. Here, the magnitudes U_{M92} and I_{M92} are given which are the results from the calibration via the M 92 standard sequence. The sums of the differences d(U) and d(I) to our basic calibration are in both cases exactly 0.000 mag. Therefore no shift in magnitude between the different calibrations can be seen. The mean differences (positive or negative) between the magnitudes of the two calibrations are 0.033 in U and 0.013 in I, resp.

The NGC 7790 field of OBH is not completely identical to our field because they chose the south eastern part of the cluster whereas we centred our frames onto the clusteris centre. In addition, not all stars have measurable U values. As the result, in the overlapping section there are 84 stars with the complete $UBVRI$ data set in common to the OBH work. The $UBVRI$ magnitudes of all our stars are listed in Table 4 with with their OBH numbers. We have chosen the notation U_s, B_s etc. The errors of the individual stellar magnitudes have been added. The last three columns of the table display the differences between the magnitudes BVR from our work and those from the OBH sequence.

We have plotted the erros versus the calibrated magnitudes for all passbands in Fig. 1. The means $< \sigma >$ of the individual errors can be read off Table 2. As expected, the mean error in the U band is fairly large: $< \sigma >= 0.032$ mag. The individual errors become large above $U = 19$ mag, but still are quite small for magnitudes below $U = 18$ mag (see Fig. 1). With only few exceptions, the individual errors in B and V are less than 0.03 mag below 19 mag. For the R band the errors are as usually quite small – less than 0.02 mag for all magnitude intervals – except for a group of stars between 17 to 18 mag which show errors of about 0.06 mag. This might be due to the effect of severe crwoding because the R fields are quite rich of stars. The errors from the I frames are fully acceptable; they are less than 0.04 mag below $I = 16$ mag.

Finally, we compare our results with those of Odewahn et al. (1992, OBH). The ranges in the magnitudes BVR and the means of the individual errors are compared in the first two sections of Table 2. The errors of our work are a bit smaller, but, in principle, the results are quite similar. The differences d(B), d(V), and d(R), in the sense "our magnitude minus OBH's magnitude", are listed in the last columns of Table 4. The differences have been plotted in Fig. 2 vs. the magnitudes of this paper. No systematic difference between the two calibrations can be seen. Indeed, the mean deviations from the zero-axes are only 0.05 mag

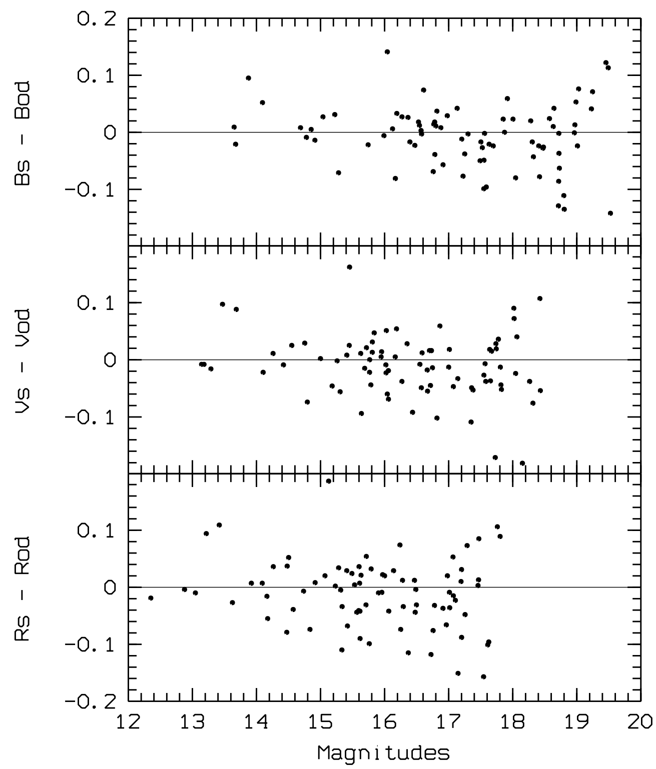

Fig. 2. Comparison of our calibrated BVR magnitudes with the corresponding magnitudes of Odewahn et al. (1992)

(see also the last column of Table 2; only star no. 106, which has the extremely large difference of 0.5 mag in all three bands, has been omitted from the calculation).

The sum of all differences in each passband gives the shift in magnitude between the two standard sequences. It is apparent from Tabel 2 (right section) that the shifts are only two thousandths of a magnitude.

We conclude that our calibration of the standard sequence in the NGC 7790 field perfectly agrees with OBH's calibration for the bands B, V, and r, and we, therefore, have an additional strong indication that our calbrations for the bands U and I are in good state, too.

5. Concluding remarks

We have constructed a primary standard sequence of 13 stars in U and I in the field of the open cluster NGC 7790. With these standards we were able to extend the B, V, and R sequences of Odewahn et al. (1992) to the two the other ones enclosing bands U and I. These new standard sequences contains 84 stars in wide ranges of magnitude and colour.

We strengthen that three reasons support the reliability of the new U and I sequences:

- We applied a three step iteration method which integrates additional stars into the process of calibration. This leads to higher accuracy for a sample of stars comprising wider intervals of magnitude and colour.
- An additional calibration, using the commonly accepted standard sequence in the globular cluster M 92 (Majewski et al. 1994), agrees very well with our primary calibration.
- A comparison of our results for the in between lying bands BVR with those of Odewahn et al. (1992) again gives perfect agreement.

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Table 2. Magnitude intervals and error budgets of standard sequences in NGC 7790 and summary of the comparison

	This paper		Odewahn et al. 1992		Difference d	
Filter	range	$< \sigma >$	range	$< \sigma >$	shift	$<\|d\|>$
U	13.61 ... 20.01	0.032				
B	13.61 ... 19.54	0.009	13.64 ... 19.67	0.024	−0.002	0.049
V	13.14 ... 18.48	0.009	13.15 ... 18.52	0.014	−0.002	0.047
R	12.35 ... 17.88	0.017	12.37 ... 17.92	0.021	+0.002	0.059
I	11.59 ... 19.67	0.015				

Table 3. U and I magnitudes of the 13 primary standard stars

No.	U_s	$\sigma(U_s)$	I_s	$\sigma(I_s)$	U_{M92}	d(U)	I_{M92}	d(I)
29	13.611	0.0110	12.782	0.0042	13.622	−0.011	12.789	−0.007
30	13.838	0.0110	12.929	0.0046	13.868	−0.030	12.935	−0.007
36	15.063	0.0090	13.917	0.0300	15.116	−0.053	13.936	−0.019
37	15.330	0.0152	14.149	0.0060	15.308	+0.021	14.142	+0.007
51	14.903	0.0131	13.865	0.0064	14.882	+0.021	13.840	+0.025
58	16.358	0.0156	14.724	0.0159	16.363	−0.005	14.754	−0.030
59	16.895	0.0150	15.302	0.0104	16.871	+0.025	15.298	+0.003
62	18.277	0.0247	13.500	0.0260	18.318	−0.041	13.488	+0.013
65	17.079	0.0121	15.080	0.0185	17.147	−0.068	15.097	−0.017
72	14.541	0.0170	13.521	0.0064	14.521	+0.020	13.513	+0.008
77	17.020	0.0142	15.074	0.0092	17.025	−0.005	15.043	+0.031
88	17.178	0.0159	14.649	0.0078	17.090	+0.088	14.654	−0.005
97	15.924	0.0406	11.593	0.0131	15.886	+0.038	11.595	−0.002

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Table 4. Magnitudes of all 84 standard stars and the errors of the individual values. The last three columns give the difference between the listed magnitudes and those from the BVR sequence of Odewahn et al. 1992

No.	U_s	$\sigma(U_s)$	B_s	$\sigma(B_s)$	V_s	$\sigma(V_s)$	R_s	$\sigma(R_s)$	I_s	$\sigma(I_s)$	d(B)	d(V)	d(R)
8	17.144	0.0130	16.912	0.0040	16.270	0.0035	15.904	0.0056	15.471	0.0070	−0.057	−0.038	−0.010
9	18.170	0.0233	18.045	0.0060	17.073	0.0049	16.497	0.0099	15.887	0.0088	−0.080	−0.047	−0.031
10	18.332	0.0254	18.479	0.0088	17.550	0.0060	16.963	0.0145	16.373	0.0131	−0.026	−0.027	−0.066
11	18.222	0.0360	17.916	0.0060	17.011	0.0060	16.466	0.0090	15.945	0.0050	+0.059	+0.018	+0.012
12	18.761	0.0300	19.010	0.0113	18.045	0.0074	17.458	0.0180	16.899	0.0106	−0.024	−0.024	+0.003
16	16.776	0.0180	16.544	0.0053	15.946	0.0063	15.610	0.0081	15.203	0.0063	+0.012	+0.005	+0.007
17	16.395	0.0102	16.168	0.0031	15.638	0.0042	15.333	0.0056	14.969	0.0061	−0.081	−0.094	−0.110
18	19.074	0.0488	19.119	0.0131	18.151	0.0063	17.545	0.0145	16.928	0.0127	−0.427	−0.181	−0.157
20	16.517	0.0180	16.271	0.0032	15.717	0.0042	15.409	0.0042	15.031	0.0049	+0.027	+0.021	+0.029
21	16.838	0.0344	16.577	0.0035	16.020	0.0033	15.709	0.0040	15.324	0.0056	−0.003	−0.009	−0.031
22	18.335	0.0226	17.204	0.0071	15.767	0.0049	14.916	0.0100	14.029	0.0102	−0.012	+0.000	+0.008
23	17.536	0.0290	16.569	0.0040	14.999	0.0035	14.090	0.0044	13.035	0.0071	+0.003	+0.002	+0.007
24	17.344	0.0170	17.250	0.0053	16.573	0.0049	16.610	0.0057	15.688	0.0053	−0.038	−0.049	+0.365
25	16.996	0.0187	16.781	0.0035	15.838	0.0032	15.282	0.0035	14.696	0.0039	+0.018	+0.047	+0.034
26	17.536	0.0220	17.503	0.0070	16.731	0.0060	16.279	0.0070	15.812	0.0060	−0.017	+0.016	+0.012
27	18.424	0.0265	18.471	0.0081	17.568	0.0057	17.016	0.0177	16.453	0.0141	−0.028	−0.007	−0.036
28	17.840	0.0269	17.587	0.0050	16.817	0.0035	16.370	0.0077	15.892	0.0085	−0.096	−0.102	−0.115
29	13.611	0.0110	13.675	0.0018	13.289	0.0028	13.047	0.0031	12.782	0.0042	−0.021	−0.016	−0.010
30	13.838	0.0110	13.875	0.0021	13.470	0.0039	13.217	0.0039	12.929	0.0046	+0.095	+0.097	+0.094
31	14.064	0.0200	14.094	0.0030	13.685	0.0030	13.419	0.0030	13.122	0.0030	+0.052	+0.088	+0.109
32	16.253	0.0117	15.990	0.0029	15.410	0.0046	15.069	0.0058	14.646	0.0069	−0.006	+0.008	+0.020
34	18.635	0.0320	18.632	0.0095	17.743	0.0088	17.201	0.0205	16.652	0.0152	+0.010	+0.019	+0.031
35	18.996	0.0390	19.490	0.0191	18.315	0.0098	17.610	0.0156	17.007	0.0138	+0.113	−0.076	−0.101
36	15.063	0.0090	15.038	0.0029	14.551	0.0042	14.263	0.0056	13.917	0.0300	+0.027	+0.025	+0.036
37	15.330	0.0152	15.222	0.0035	14.753	0.0064	14.479	0.0040	14.149	0.0060	+0.031	+0.029	+0.037
38	17.077	0.0159	16.816	0.0046	16.186	0.0057	15.790	0.0057	15.348	0.0057	+0.037	+0.054	+0.032
39	18.970	0.0570	18.728	0.0200	17.640	0.0120	16.980	0.0480	16.191	0.0340	−0.063	+0.018	+0.020
40	19.362	0.0760	18.970	0.0260	17.776	0.0100	17.067	0.0420	16.264	0.0630	+0.013	+0.036	+0.053
41	18.772	0.0390	18.643	0.0200	17.737	0.0120	17.193	0.0580	16.593	0.0490	+0.042	+0.028	+0.010
42	19.194	0.0660	18.967	0.0350	17.930	0.0440	17.351	0.0670	16.760	0.0410	+0.249	+0.341	+0.431
43	19.202	0.0371	19.455	0.0159	18.424	0.0120	17.803	0.0237	17.260	0.0279	+0.122	+0.107	+0.089
45	16.646	0.0141	16.365	0.0039	15.809	0.0042	15.490	0.0039	15.119	0.0056	+0.026	+0.031	+0.024
48	16.470	0.0441	16.124	0.0028	15.259	0.0038	14.735	0.0065	14.191	0.0065	+0.006	−0.002	−0.007
49	18.895	0.0500	18.280	0.0220	16.585	0.0120	15.601	0.0130	14.526	0.0110	+0.020	+0.012	+0.036
51	14.903	0.0131	14.854	0.0032	14.421	0.0064	14.163	0.0071	13.865	0.0064	+0.005	−0.009	−0.016
53	17.305	0.0177	16.978	0.0042	16.351	0.0064	16.000	0.0067	15.597	0.0078	+0.029	+0.028	+0.020
54	17.773	0.0210	17.560	0.0057	16.551	0.0078	15.969	0.0134	15.366	0.0177	−0.002	−0.008	+0.022
55	18.653	0.0440	18.987	0.0100	18.021	0.0170	17.471	0.0200	17.030	0.0170	+0.053	+0.072	+0.085
56	19.338	0.0650	19.246	0.0310	18.263	0.0140	17.626	0.0500	16.982	0.0370	+0.071	−0.038	−0.096
58	16.358	0.0156	16.042	0.0085	15.453	0.0134	15.127	0.0131	14.724	0.0159	+0.141	+0.162	+0.186
59	16.895	0.0150	16.609	0.0038	16.027	0.0052	15.715	0.0081	15.302	0.0104	+0.074	+0.051	+0.054
60	18.356	0.0210	18.004	0.0085	16.863	0.0088	16.239	0.0156	15.601	0.0187	+0.023	+0.059	+0.074
62	18.277	0.0247	17.132	0.0056	15.448	0.0085	14.502	0.0145	13.500	0.0260	+0.042	+0.025	+0.052
65	17.079	0.0121	16.768	0.0040	16.022	0.0058	15.595	0.0071	15.080	0.0185	+0.014	−0.023	−0.041
66	16.866	0.0205	16.529	0.0039	15.953	0.0046	15.632	0.0049	15.259	0.0053	+0.018	+0.014	+0.021
67	18.046	0.0631	17.872	0.0052	17.000	0.0052	16.487	0.0092	15.943	0.0104	+0.000	−0.013	−0.004
68	18.591	0.0258	18.717	0.0117	17.652	0.0081	17.012	0.0163	16.375	0.0138	−0.086	−0.037	−0.009
69	19.050	0.0640	18.797	0.0220	17.824	0.0110	17.202	0.0430	16.505	0.0290	−0.111	−0.052	−0.088
72	14.541	0.0170	14.780	0.0028	14.259	0.0064	13.920	0.0078	13.521	0.0064	−0.009	+0.011	+0.007
73	17.844	0.0265	17.302	0.0057	16.166	0.0067	15.531	0.0085	14.943	0.0074	−0.003	+0.005	+0.004
74	18.302	0.0788	18.323	0.0095	17.358	0.0085	16.779	0.0226	16.217	0.0247	−0.043	−0.049	−0.032
75	18.702	0.0330	18.713	0.0103	17.727	0.0085	17.146	0.0180	16.607	0.0152	−0.129	−0.171	−0.151
76	18.974	0.0450	18.804	0.0220	17.965	0.0140	17.445	0.0480	16.930	0.0470	−0.135	−0.229	−0.335
77	17.020	0.0142	16.759	0.0042	16.042	0.0060	15.615	0.0083	15.074	0.0092	−0.069	−0.060	−0.042
78	19.037	0.0590	19.028	0.0230	18.065	0.0150	17.466	0.0520	16.799	0.0390	+0.076	+0.040	+0.013
79	20.099	0.1240	19.228	0.0230	18.017	0.0130	17.288	0.0540	16.577	0.0410	+0.041	+0.090	+0.073

Table 4. Continued

No.	U_s	$\sigma(U_s)$	B_s	$\sigma(B_s)$	V_s	$\sigma(V_s)$	R_s	$\sigma(R_s)$	I_s	$\sigma(I_s)$	d(B)	d(V)	d(R)
80	16.368	0.0134	16.190	0.0057	15.627	0.0092	15.314	0.0095	14.925	0.0103	+0.033	+0.011	−0.005
82	14.045	0.0120	13.651	0.0028	13.144	0.0057	12.877	0.0071	12.505	0.0067	+0.009	−0.008	−0.004
83	17.294	0.0166	16.878	0.0046	16.059	0.0060	15.566	0.0064	15.014	0.0064	+0.008	−0.019	−0.044
84	19.413	0.0860	19.525	0.0360	18.431	0.0230	17.760	0.0510	16.951	0.0470	−0.142	−0.054	+0.106
85	17.684	0.0192	17.631	0.0048	16.701	0.0056	16.140	0.0104	15.553	0.0075	−0.021	+0.016	+0.029
86	17.802	0.0198	17.695	0.0078	16.670	0.0081	16.065	0.0085	15.457	0.0074	−0.024	−0.055	−0.042
87	18.584	0.0308	18.719	0.0113	17.816	0.0103	17.256	0.0223	16.778	0.0240	−0.002	−0.044	−0.048
88	17.178	0.0159	16.799	0.0057	15.808	0.0088	15.231	0.0088	14.649	0.0078	+0.011	+0.013	+0.002
90	18.688	0.0400	18.573	0.0230	17.669	0.0130	17.073	0.0430	16.345	0.0210	+0.024	+0.015	−0.015
94	17.156	0.0197	16.784	0.0044	16.060	0.0058	15.617	0.0069	15.136	0.0085	−0.039	−0.069	−0.090
95	16.674	0.0108	16.395	0.0044	15.785	0.0062	15.420	0.0069	14.970	0.0087	−0.017	−0.044	−0.068
96	16.786	0.0227	16.472	0.0040	15.765	0.0067	15.337	0.0079	14.834	0.0079	−0.023	−0.022	−0.034
97	15.924	0.0406	14.688	0.0038	13.181	0.0058	12.351	0.0078	11.593	0.0131	+0.008	−0.008	−0.019
98	15.138	0.0081	14.912	0.0042	14.104	0.0067	13.625	0.0094	13.145	0.0096	−0.014	−0.022	−0.027
99	17.787	0.0212	17.525	0.0056	16.747	0.0067	16.292	0.0011	15.767	0.0096	−0.027	−0.014	−0.034
100	19.232	0.0760	18.962	0.0270	17.807	0.0160	17.105	0.0460	16.322	0.0290	−0.001	−0.013	−0.023
103	17.836	0.0440	17.490	0.0056	16.716	0.0071	16.251	0.0100	15.787	0.0108	−0.050	−0.045	−0.074
104	15.884	0.0112	15.743	0.0050	15.181	0.0064	14.835	0.0085	14.474	0.0075	−0.022	−0.046	−0.074
105	18.816	0.0399	17.551	0.0088	15.689	0.0106	14.573	0.0159	13.319	0.0166	−0.049	−0.015	−0.039
106	18.444	0.0540	19.099	0.0170	17.937	0.0160	17.299	0.0170	16.812	0.0150	+0.527	+0.504	+0.545
107	18.586	0.0371	17.224	0.0092	15.306	0.0106	14.175	0.0141	12.828	0.0166	−0.077	−0.056	−0.055
108	18.619	0.0325	18.305	0.0099	17.142	0.0103	16.477	0.0184	15.839	0.0148	−0.017	−0.033	−0.044
109	18.443	0.0275	18.406	0.0117	17.380	0.0110	16.757	0.0209	16.156	0.0131	−0.024	−0.053	−0.076
110	18.048	0.0390	17.851	0.0070	16.665	0.0090	15.957	0.0140	15.322	0.0080	+0.023	−0.018	−0.009
112	17.527	0.0270	17.548	0.0060	16.436	0.0090	15.761	0.0070	15.094	0.0070	−0.099	−0.092	−0.099
113	15.318	0.0160	15.281	0.0070	14.794	0.0120	14.473	0.0570	14.072	0.0180	−0.071	−0.074	−0.079
114	18.116	0.0380	18.418	0.0120	17.350	0.0140	16.724	0.0110	16.154	0.0110	−0.078	−0.109	−0.118
115	18.432	0.0480	18.721	0.0120	17.578	0.0150	16.911	0.0160	16.381	0.0140	−0.037	−0.038	−0.037