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Photometric accuracy. The impact of extrapolation in differing color-transformation schemes*

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Abstract. We discuss photometric errors that arise from the use of differing color-transformation schemes when extrapolating outside the range of the standard values that define the system. An example based on data from the Long-Term Photometry of Variables project (LTPV) at ESO is analyzed. Practically, the extrapolation errors are most evident as systematic brightness jumps of some programme stars, seen when monitored over several observing runs. Conclusions are drawn about the choice of standard stars in the Strömgren system.

Key words: photometry – data processing – homogenization

1. Introduction

In preceding studies (Manfroid 1985; Manfroid & Sterken 1987, 1991, 1992; Sterken & Manfroid 1987) we have investigated photometric errors arising from the non-conformity of passbands, as well as reduction errors due to uncertainties in the determination of the reduction parameters.

In the present article, we show how another variety of reduction errors appears when transformation equations of different nature are applied to a given set of data. Contrarily to the usual reduction errors (Manfroid & Sterken 1991, 1992) which appear as random shifts from one observing run to the other, the extrapolation errors are essentially systematic, method-dependent, shifts. They show up for stars having color indices that fall outside the range of standard values, where the color-transformation relations are necessarily extrapolated. As it is often the case with extrapolations, the errors rapidly grow to unacceptable levels.

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2. Data analysis

The data discussed here were obtained in June 1986 (JD 2 446 581–2 446 609) by H. Steenman, in the framework of the Long-Term Photometry of Variables (LTPV) programme (Sterken 1983, 1986) at the ESO La Silla observatory, with the University of Copenhagen's 50 cm telescope, in the Strömgren *uvby* system.

The color transformation equation is

$$\mathbf{U}_s = \mathbf{M}\mathbf{U}_0 + \mathbf{K} \tag{1}$$

where $\mathbf{U}$ is the vector of indices:

$$\mathbf{U} = \begin{pmatrix} b-y \\ y \\ m_1 \\ c_1 \end{pmatrix} \tag{2}$$

The suffixes s and 0 respectively denote the standard and instrumental values. $\mathbf{K}$ is the vector of zero-points. The general color-transformation matrix $\mathbf{M}$ is written as

$$\mathbf{M} = \begin{pmatrix} m_{11} & 0 & m_{13} & m_{14} \\ m_{21} & 1 & m_{23} & m_{24} \\ m_{31} & 0 & m_{33} & m_{34} \\ m_{41} & 0 & m_{43} & m_{44} \end{pmatrix} \tag{3}$$

but, in practice (see, e.g., Crawford & Barnes 1970) 6 parameters are generally omitted, i.e.,

$$m_{13} = m_{14} = m_{23} = m_{24} = m_{34} = m_{43} = 0 \tag{4}$$

The reductions were carried out with the PHOT2 algorithm (Manfroid 1985), with standard stars taken from the list of Olsen (1983), supplemented by a few stars from Olsen (1984). A complete description of the reduction procedure followed for the LTPV programme is given in Manfroid et al. (1991a, b).

Following the established procedure of the LTPV reductions, the June 1986 observing run was originally reduced using a linear color-transformation equation with 6 independent parameters (Eqs. 3, 4). Because of the relatively poor color fit obtained this way, also the 12-parameter option was tried. However, the improvement was only marginal, amounting to a maximum of a few thousandths of a magnitude over the whole range of standard values. The data were later re-reduced with the 6-parameter variant (Eqs. 3, 4) for sake of homogeneity with other data obtained by other observers.

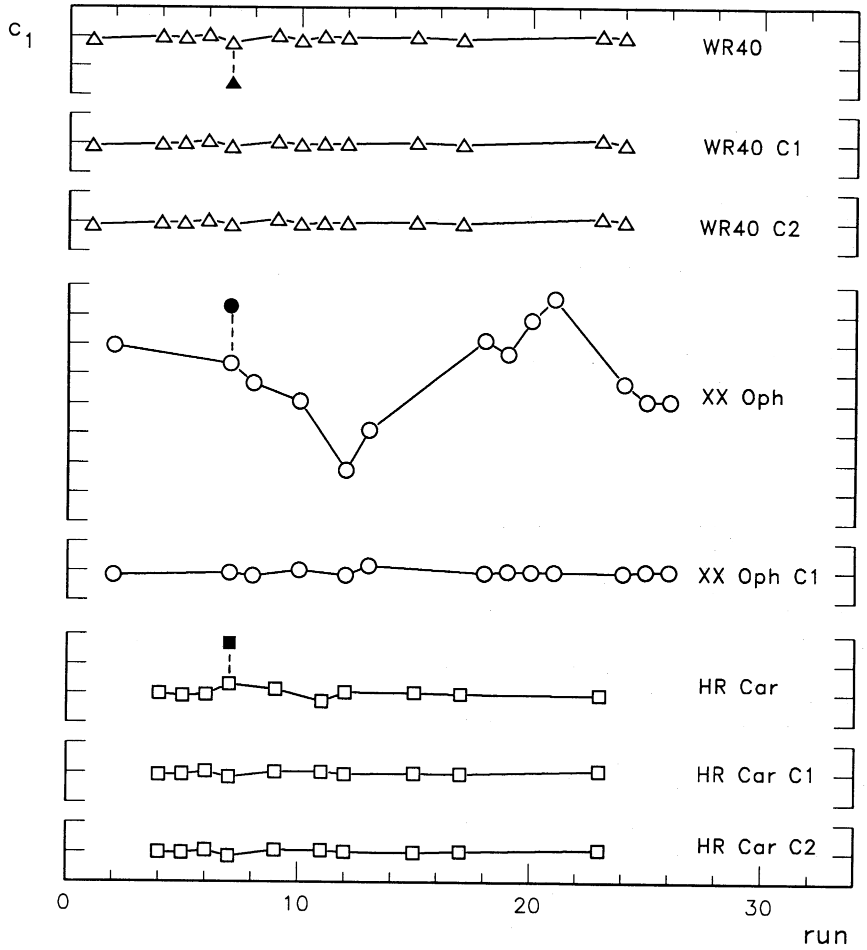

Fig. 1. Median color index c_1 of three variable stars and of their comparisons, for several observing runs (labelled 1 to 26) at the ESO SAT telescope. Tick marks on the vertical axis are separated by 0.1 mag. The same symbols are used for each variable and its comparisons (C1, C2). All data sets were reduced with the 6-parameter color transformation. Data set #7 was also reduced with a 12-parameter color transformation, and these results are indicated by solid symbols when they differ significantly from results obtained through the 6-parameter set.

When comparing both sets of reduced data (Table 1), it is seen that the agreement is indeed very good inside the range of standard values – which is rather limited in *uvby* –, but that, outside that range, the two reduction methods yield markedly different results. Examination of Table 1 shows that the color index c_1 is much more affected than the other indices or the y magnitude. It also appears that, besides objects with intrinsically peculiar indices, heavily reddened stars show large effects too. Almost inevitably, those stars are hot supergiants, so that it is difficult to disentangle the effects due to intrinsic peculiarities from those caused by interstellar extinction. This was to be expected since reddening is known to be badly handled by color transformations, as was shown by the simulations worked out by Manfroid (1985).

From Table 1, we can notice a few objects for which the effect is particularly large: Wolf-Rayet stars, hot supergiants and/or Luminous Blue Variable candidates and a lot of K- and M-type stars.

An illustrative example is given in Fig. 1, where the median value of the c_1 index over an observing run is plotted for various stars and for several runs. All observing runs were carried out at the ESO SAT telescope, and all data sets were reduced with the 6-parameter color transformation, with the exception of run #7 (June 86) where the 12- and 6-parameter transformations have been used. Three variable stars are presented (the peculiar object HD 161114≡XX Oph, the LBV HD 90177≡HR Car and the Wolf-Rayet HD 96548≡WR40) together with their comparison stars: SAO142339 (spectral type B3) for HD 161114; HD 93010 (B3III) and HD 93502 (A0IV) for HD 90177; HD 96287 (B9.5V) and HD 96568 (A3V) for HD 96548.

3. Discussion

Although more complex color transformations can give better results within the range of indices of the standard stars, this is not the case outside that range, and consequently it is not the case for some particular programme stars. All criteria used to estimate the accuracy rely upon stars with "normal" indices and are unlikely to point toward a problem concerning more peculiar stars. Hence, the addition of parameters – or any change in the analytical expression of the transformation – is to be handled with great care. In the present paper we compared linear color-transformation relations with 6 or with 12 parameters, but similar comments apply to non-linear schemes where extrapolation effects are even more dramatic.

The differences between the calculations made with both procedures can be very large (up to .2 mag or more) for exotic stars, and these differences systematically repeat for any data set obtained with the same equipment. Thus, if a series of data sets is processed with different color-transformation relations, it should be expected that some of the most peculiar stars will exhibit bi-, tri-, or multi-modal distributions of photometric values, according to the number of different relations used. Since the effect manifests itself for a few exotic objects only, it could easily be misinterpreted as an intrinsic behavior of the stars.

Table 1. Differences $\delta(b-y)$, δy, δm_1, δc_1 between the 12- and 6-parameter reductions for several typical LTPV stars. Mean $b-y$, y, m_1 and c_1 values are given in the rightmost columns.

HD	Other ID	Spectrum	$\delta(b-y)$	δy	δm_1	δc_1	$(b-y)$	y	m_1	c_1
HD 86161	CpD-57 2420	WN8	0.008	-0.006	-0.022	0.125	0.059	8.273	0.400	-0.142
HD 96548	CpD-64 1629	WN8	0.015	-0.010	-0.029	0.181	0.122	7.697	0.510	-0.094
HD168112	BD-12 4988	O5.5	-0.016	0.008	0.005	-0.091	0.544	8.543	-0.077	-0.131
HD167263	BD-20 5055	O9II	-0.009	0.003	-0.006	-0.010	0.081	5.975	0.009	-0.106
HD152424	CoD-41 11068	B0Ib/II	-0.013	0.007	0.000	-0.064	0.371	6.314	-0.056	-0.105
HD102368	CpD-61 2611	B0III	-0.010	0.005	-0.005	-0.028	0.112	7.596	-0.033	-0.065
HD167264	BD-20 5054	B0Ia	-0.009	0.003	-0.006	-0.012	0.097	5.338	0.010	-0.110
HD152147	CpD-41 7694	B0Ia	-0.013	0.007	0.000	-0.061	0.361	7.282	-0.049	-0.105
HD184279	BD+03 4065	B0.5IV	-0.008	0.005	-0.006	-0.027	0.107	6.871	-0.032	0.015
HD160575	CoD-35 11827	B1/B2II	-0.011	0.006	0.001	-0.058	0.323	7.626	-0.035	0.043
HD125721	CoD-47 9082	B1III	-0.007	0.002	-0.007	0.001	-0.009	6.090	0.019	-0.009
HD173219	BD-07 4689	B1V:npe	-0.012	0.005	-0.003	-0.044	0.217	7.864	-0.053	-0.124
HD152236	CoD-42 11633	B1Iape	-0.014	0.008	0.002	-0.079	0.443	4.754	-0.074	-0.117
HD102567	CpD-61 2636	B1Vne	-0.012	0.006	-0.003	-0.044	0.214	8.998	-0.057	-0.155
HD148605	CoD-24 12695	B2V	-0.003	0.001	-0.008	0.021	-0.050	4.801	0.088	0.206
HD181615	BD-16 5283	B2Vpe+...	-0.002	0.000	-0.010	0.020	0.093	4.566	0.117	0.119
HD 94910	CpD-59 2860	B2:pe	-0.014	0.006	-0.001	-0.062	0.409	7.978	-0.048	-0.198
HD 90177	CpD-58 2145	B2evar	-0.022	0.011	0.011	-0.141	0.770	8.091	-0.152	-0.172
HD127381	CoD-49 8831	B2III	-0.003	0.001	-0.010	0.025	-0.067	4.434	0.079	0.049
HD149711	CoD-43 10959	B2.5IV	-0.004	0.001	-0.005	0.000	0.023	5.851	0.061	0.268
	SAO142339	B3	-0.003	0.001	0.002	-0.019	0.400	10.146	0.157	0.418
HD 92287	CpD-56 3588	B3IV	-0.002	0.001	-0.006	0.008	-0.038	5.882	0.068	0.354
HD 93010	CpD-60 2203	B3III	-0.004	0.002	-0.002	-0.012	0.049	6.618	0.041	0.356
HD168552	BD-17 5149	B3Ib	-0.010	0.005	0.001	-0.048	0.286	8.097	-0.010	0.119
HD167233	CoD-36 12388	B3III	-0.005	0.002	-0.004	-0.006	0.001	6.854	0.037	0.290
HD150742	CoD-40 10661	B3V	-0.003	0.000	-0.005	0.007	-0.021	5.647	0.071	0.315
HD 89890	CpD-55 3286	B3IIIe	-0.001	0.000	-0.006	0.014	-0.039	4.486	0.093	0.420
HD 92399	CpD-58 2462	B4/B5III/IV	-0.003	0.001	-0.004	0.001	-0.025	6.505	0.059	0.407
HD142983	BD-13 4302	B5IIIpe	-0.001	0.001	-0.002	0.001	-0.011	4.867	0.080	0.538
HD143699	CoD-38 10832	B6IV	-0.001	0.000	-0.007	0.020	-0.063	4.903	0.100	0.367
HD150591	CoD-40 10653	B6.5V	-0.002	0.001	-0.003	0.001	-0.005	6.151	0.070	0.435
HD115967	CpD-71 1467	B6V	-0.003	0.003	0.002	-0.023	0.105	6.051	0.053	0.565
HD183227	BD+02 3892	B6III	-0.003	0.002	0.000	-0.015	0.048	5.862	0.056	0.607
HD110506	CpD-55 5197	B7.5V	0.001	0.000	-0.002	0.002	-0.019	5.989	0.097	0.732
HD168733	CoD-36 12524	B7Ib/II	-0.001	0.000	-0.004	0.013	-0.054	5.346	0.100	0.538
HD 5737	CoD-30 297	B7IIIp	0.000	0.000	-0.007	0.023	-0.074	4.330	0.112	0.473
HD 98143	CpD-76 657	B8III	-0.007	0.006	0.012	-0.084	0.441	7.575	0.012	0.807
HD169679	CoD-36 12632	B8/B9III	-0.001	0.001	0.004	-0.021	0.026	7.131	0.063	0.817
HD 92421	CpD-58 2471	B8III	-0.002	0.001	-0.003	-0.001	-0.007	7.731	0.069	0.476
HD108531	CpD-61 3208	B8V	-0.002	0.001	0.002	-0.016	0.056	8.236	0.077	0.704
HD 315	BD-03 2	B8IIIsp...	0.001	-0.001	-0.006	0.022	-0.076	6.461	0.117	0.566
HD 86000	CpD-54 2842	B8/B9IV:	-0.001	0.001	-0.001	0.000	0.013	8.129	0.098	0.642
HD114911	CpD-67 2224	B8V	0.000	0.000	-0.003	0.009	-0.027	4.775	0.109	0.623
HD 85810	CpD-54 2808	B8IV/V	-0.002	0.000	-0.002	-0.001	-0.012	7.943	0.077	0.567
HD151771	CoD-37 11023	B8II/III	-0.004	0.003	0.007	-0.042	0.139	6.111	0.038	0.823
HD159376	BD-21 4659	B8p	-0.002	0.001	0.002	-0.012	0.049	6.498	0.081	0.673
HD166937	BD-21 4908	B8Iape	-0.007	0.004	0.000	-0.026	0.215	3.828	0.045	0.183
HD168625	BD-16 4830	B8Ia:	-0.025	0.014	0.023	-0.200	1.100	8.430	-0.175	0.124
HD116579	CpD-74 1059	B9V	0.000	0.000	0.002	-0.009	0.000	6.613	0.089	0.818
HD 90882	BD-02 3155	B9.5V	0.003	-0.001	0.002	0.003	-0.029	5.200	0.132	1.013
HD101431	CoD-34 7610	B9V	0.001	0.000	0.002	-0.005	-0.021	4.700	0.109	0.944
HD177123	CoD-38 13316	B9IV	-0.001	0.001	0.003	-0.017	0.075	7.713	0.088	0.792
HD 96287	CpD-63 1819	B9.5V	0.001	0.000	0.004	-0.009	0.023	7.230	0.113	0.939
HD 97300	CpD-75 714	B9V	-0.005	0.004	0.012	-0.069	0.313	8.990	0.029	0.955
HD 90044	BD-03 2911	B9sp...	0.006	-0.003	-0.004	0.036	-0.082	5.975	0.197	0.877
HD103192	CoD-33 8018	B9IIIsp...	0.002	-0.002	-0.003	0.020	-0.050	4.284	0.145	0.714
HD168607	BD-16 4829	B9Ia	-0.027	0.016	0.025	-0.222	1.227	8.213	-0.215	-0.028
HD161114	BD-06 4638	Ape	-0.025	0.014	0.021	-0.188	0.864	9.058	-0.229	0.072
HD116458	CpD-69 1838	Ap...	0.003	-0.002	-0.001	0.020	-0.017	5.659	0.176	0.863
HD187474	CoD-40 13514	Ap...	0.006	-0.003	-0.005	0.047	-0.063	5.302	0.237	0.814
HD 94724	CoD-42 6595	A0V	0.001	0.000	0.005	-0.004	0.042	6.411	0.136	0.926
HD114570	CpD-65 2201	A0Vm...	0.002	0.000	0.005	-0.011	0.049	5.898	0.128	1.079
HD183324	BD+01 4010	A0V	0.004	-0.002	0.002	0.006	0.043	5.806	0.168	1.026
HD188350	BD-00 3871	A0III	0.001	0.000	0.007	-0.026	0.088	5.635	0.098	1.122
HD 94715	CpD-59 2833	A0/A1V	0.000	0.000	0.006	-0.015	0.085	9.643	0.130	1.015
HD 93502	CpD-59 2671	A0IV	0.003	-0.001	0.003	0.004	0.024	6.266	0.158	1.017
HD 97048	CpD-76 654	A0pshe	-0.002	0.003	0.010	-0.049	0.274	8.438	0.081	0.993
HD 94660	CoD-41 6220	A0sp...	0.004	-0.003	-0.003	0.038	-0.072	6.120	0.202	0.768

Table 1. (continued)

HD	Other ID	Spectrum	$\delta(b-y)$	δy	δm_1	δc_1	$(b-y)$	y	m_1	c_1
HD183656	BD+03 4043	A0she	-0.001	0.001	0.005	-0.028	0.044	6.092	0.056	0.942
HD 92207	CpD-58 2411	A0Iae	-0.011	0.006	0.007	-0.078	0.431	5.486	-0.022	0.354
HD160461	CoD-34 11950	A1V	0.001	0.000	0.008	-0.027	0.110	7.521	0.116	1.158
HD189388	CoD-41 13807	A2.5V	0.004	-0.002	0.003	0.006	0.055	6.316	0.180	1.036
HD222095	CoD-46 14720	A2V	0.004	-0.002	0.004	0.006	0.038	4.757	0.186	1.097
HD221760	CoD-43 15420	A2Vp...	0.005	-0.002	0.003	0.010	0.042	4.721	0.191	1.072
HD153072	CoD-37 11131	A3V	0.003	-0.002	0.003	0.003	0.101	6.065	0.178	0.945
HD 96568	CpD-64 1630	A3V	0.003	0.000	0.006	-0.008	0.074	6.391	0.159	1.138
HD160529	CoD-33 12361	A3Iae	-0.022	0.013	0.022	-0.179	0.949	6.789	-0.147	0.274
HD 93453	CoD-42 6484	A4IV	0.002	-0.001	0.004	0.003	0.110	6.294	0.184	0.925
HD188041	BD-03 4742	A5pvar	0.008	-0.005	-0.007	0.062	0.049	5.664	0.312	0.765
HD223011	CoD-40 15239	A7III-IV	0.004	-0.002	0.001	0.008	0.115	6.327	0.188	0.885
HD 3326	CoD-23 220	A7p	0.004	-0.001	-0.003	0.018	0.170	6.068	0.215	0.746
HD165040	CpD-63 4292	A7sp...	0.005	-0.003	0.001	0.021	0.137	4.333	0.239	0.902
HD106086	CpD-59 4097	A8IV	0.002	-0.001	0.004	-0.004	0.154	6.818	0.175	0.964
HD 4247	CoD-22 239	FIII-IV	0.000	0.000	-0.002	-0.001	0.221	5.231	0.152	0.556
HD160627	CoD-26 12252	F0V	0.000	0.001	0.001	-0.008	0.251	8.100	0.154	0.647
HD145191	CoD-40 10251	F0IV	0.002	-0.001	0.003	0.003	0.161	5.866	0.187	0.841
HD201601	BD+09 4732	F0p	0.004	-0.002	-0.002	0.028	0.142	4.717	0.243	0.764
HD156897	BD-20 4731	F1III-IV	-0.001	0.001	0.000	-0.003	0.248	4.397	0.159	0.497
HD179034	CpD-51 11161	F2/F3III	0.000	0.001	0.008	-0.029	0.305	8.075	0.152	0.927
HD105841	CpD-60 3812	F2.5IV	0.000	0.001	0.003	-0.014	0.269	6.074	0.153	0.703
HD152216	CoD-35 11158	F3V	-0.003	0.002	0.001	-0.017	0.307	9.391	0.128	0.421
HD185124	BD-04 4861	F3IV	0.000	0.000	-0.001	0.000	0.262	5.461	0.175	0.536
HD100613	CpD-58 3717	F3/F5IV/V	-0.002	0.001	0.003	-0.019	0.306	7.251	0.144	0.610
HD202275	BD+09 4746	F5V+...	-0.001	0.001	-0.001	-0.001	0.313	4.509	0.174	0.392
HD191889	CoD-38 13920	F5V	-0.002	0.001	0.000	-0.013	0.296	6.896	0.139	0.472
HD101684	CpD-63 1943	F5Iab/Ib	-0.005	0.003	0.020	-0.065	0.639	7.236	0.189	0.963
HD160915	BD-21 4712	F6V	-0.003	0.001	0.000	-0.008	0.298	4.880	0.154	0.418
HD111199	BD-05 3569	F7V	-0.001	0.001	0.000	-0.010	0.342	6.279	0.165	0.494
HD143333	BD-16 4196	F8V	-0.001	0.001	0.000	-0.009	0.324	5.470	0.163	0.451
HD177300	CoD-51 11917	F8Iab:+...	-0.001	0.002	0.014	-0.056	0.373	7.174	0.123	1.192
HD165499	CpD-62 5797	G0V	-0.003	0.001	0.000	-0.013	0.390	5.472	0.163	0.361
HD180702	CoD-33 14114	G1V	-0.003	0.001	0.000	-0.012	0.372	6.945	0.161	0.384
HD105998	CpD-58 4151	G2Iab	0.000	0.000	0.004	-0.018	0.715	8.361	0.282	0.536
HD 73524	CoD-39 4574	G4IV-V	-0.002	0.001	0.001	-0.012	0.368	6.444	0.169	0.415
HD204075	CoD-22 15388	G4Iab:	0.006	-0.004	-0.010	0.063	0.598	3.766	0.440	0.150
HD106552	CpD-58 4192	G5V	-0.002	0.001	-0.001	-0.006	0.433	8.300	0.197	0.381
HD204381	BD-22 5692	G5III	0.004	-0.003	-0.004	0.030	0.544	4.523	0.351	0.391
HD131530	BD-11 3827	G7III	0.005	-0.003	-0.003	0.038	0.601	5.790	0.398	0.420
HD100445	CpD-64 1674	G8III/IV	-0.001	0.001	0.004	-0.018	0.785	9.079	0.290	0.364
HD100122	CpD-58 3677	G8/K0III+...	-0.001	0.001	0.001	-0.008	0.544	7.656	0.234	0.379
HD130952	BD-01 2991	G8III	0.003	-0.002	-0.002	0.026	0.600	4.933	0.364	0.415
HD 92626	CpD-47 4419	G8/K0p...	0.015	-0.009	-0.020	0.141	0.828	7.072	0.723	-0.124
HD181645	BD-18 5325	G9III:	0.007	-0.004	-0.005	0.043	0.656	5.848	0.429	0.468
HD 73829	CpD-42 2773	K0III	0.010	-0.005	-0.003	0.062	0.740	9.440	0.531	0.486
HD184944	BD+14 3974	K0II-III	0.010	-0.005	-0.012	0.078	0.633	6.380	0.500	0.281
HD139195	BD+10 2884	K0III:CNs...	0.005	-0.003	-0.004	0.045	0.564	5.271	0.401	0.353
HD116713	CoD-39 8246	K0.5III:...	0.011	-0.007	-0.015	0.110	0.727	5.109	0.612	0.000
HD154430	CpD-59 6905	K1III	0.017	-0.010	-0.016	0.134	1.008	8.709	0.790	0.061
HD174208	BD-06 4922	K2Ib	0.010	-0.006	-0.005	0.070	1.059	5.964	0.636	0.238
HD161406	CoD-27 11914	K2III:	0.008	-0.004	-0.002	0.039	1.326	8.635	0.631	0.258
HD 90677	CpD-54 3651	K3II-III	0.016	-0.009	-0.014	0.125	0.979	5.539	0.767	0.221
HD130970	BD+00 3253	K3III	0.016	-0.009	-0.009	0.114	0.878	6.157	0.729	0.400
HD116835	CoD-40 7894	K3III	0.017	-0.009	-0.012	0.124	0.939	5.652	0.766	0.302
HD114873	CoD-42 8213	K4III	0.014	-0.008	-0.006	0.097	0.880	6.120	0.685	0.405
HD172348	BD-07 4648	K4III	0.015	-0.009	-0.009	0.102	1.006	5.816	0.729	0.361
HD131918	BD-10 3989	K4III	0.016	-0.009	-0.012	0.118	0.932	5.447	0.745	0.326
HD117246	BD-17 3862	K4III	0.013	-0.007	-0.006	0.088	0.887	6.862	0.656	0.387
HD204139	BD-21 6020	K5III	0.017	-0.010	-0.012	0.126	0.901	5.754	0.765	0.371
HD 87808	BD-16 2974	K5III	0.018	-0.010	-0.013	0.133	0.939	5.563	0.797	0.372
HD161387	CoD-26 12327	K5Ib+...	-0.005	0.003	0.004	-0.049	1.245	8.600	0.304	-0.016
HD178717	BD+10 3801	K5	0.019	-0.011	-0.021	0.162	1.224	7.153	0.920	-0.146
HD100336	BD-65 11298	Mpe	-0.015	0.006	-0.014	-0.015	0.937	10.761	0.154	-1.301
HD121447	BD-17 3961	Mp	0.022	-0.014	-0.024	0.208	1.131	7.824	1.028	-0.271
HD117970	CoD-24 10977	MIII:pe	-0.001	0.000	-0.014	0.045	1.011	8.932	0.431	-0.691
HD155341	CpD-56 8098	M1/M2II/III+.	-0.005	0.003	0.007	-0.050	1.260	6.058	0.328	0.107
HD167559	CpD-66 3311	M2/M3	0.007	-0.004	0.005	0.023	1.158	9.077	0.571	0.545
HD101712	CpD-62 2234	M3Iab:...	-0.017	0.008	0.017	-0.107	1.382	7.592	0.182	-0.268
HD182040	BD-10 5057	C...	-0.008	0.005	0.003	-0.056	0.801	7.139	0.140	0.122

Such multi-modal values – except perhaps one – are certainly wrong, but it is difficult to decide which value, if any, is correct, since the color indices of such exotic stars in the "true" standard system are not known (to the extent that such a system can still exist after the various "refinements" incurred to the *uvby* standard values).

The major errors appear in c_1, while only relatively small effects show up for m_1, and almost none at all in y and b. This is to be attributed to the less-than-ideal distribution of standard values in the Strömgren system. It is certainly difficult to find bona fide standard stars with indices similar to those of emission-line objects such as Wolf-Rayet stars. However, in view of the very large uncertainties in these areas of the color diagrams, it would be worthwhile to incorporate measurements of those stars in the standard system. On the other hand, heavily reddened standards can be found. The problem is that the brightest reddened stars are supergiants, with complex variability patterns on short and long time-scales. Fainter objects should then be adopted, but those standard-star measurements should be carried out with considerable care.

Note that differential photometry is not free from the extrapolation errors since comparison stars are usually selected among objects with non-exotic colors and do not reveal any such jumps.

Because of these extrapolation errors, the first internal releases of the LTPV data showed a few bimodal values which were corrected when the 12-parameter reductions were replaced by 6-parameter reductions. In the final LTPV release all data were homogenized (Manfroid et al. 1991a, b), thus excluding inter-run shifts, and the color transformation was carried out with a 6-parameter color matrix.

The extrapolation errors, together with the reduction errors discussed by Manfroid & Sterken (1992), and the general conformity errors, point toward the inherent difficulty of performing absolute photometry of very peculiar objects such as, for example, Wolf-Rayet stars, Luminous Blue Variables, cataclysmic variables, supernovae and also quasars.

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