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NEW CALIBRATION OF THE VILNIUS PHOTOMETRIC SYSTEM. I. EFFECTIVE TEMPERATURES AND GRAVITIES OF B-TYPE STARS

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Abstract. Colour indices and reddening-free Q-parameters in the Vilnius photometric system of B-type stars of all luminosities and A-supergiants are calibrated in terms of effective temperature and surface gravity, using synthetic spectra of the newest Kurucz model atmospheres. The calibration is verified by comparing the photometrically determined effective temperatures and surface gravities with the most accurate spectroscopic data. Satisfactory agreement has been found, proving the accuracy of the calibration within ±0.02 to ±0.05 dex in $\log T_e$ and ±0.2 to ±0.3 dex in $\log g$.

Key words: Vilnius photometric system – effective temperatures – surface gravities – stellar model atmospheres

1. Introduction

The seven-colour Vilnius photometric system makes possible the quantification of stars of all temperatures in terms of spectral classes and absolute magnitudes or in temperatures and surface gravities in the presence of interstellar reddening. The parameters of bandpasses of the system are given in Table 1. The system recently was described in detail in the Straižys (1992) monograph.

Table 1. Mean wavelengths and half-widths of bandpasses of the Vilnius photometric system

Bandpass	*U*	*P*	*X*	*Y*	*Z*	*V*	*S*
λ_0 (nm)	345	374	405	466	516	544	656
$\Delta\lambda$ (nm)	40	26	22	26	21	26	20

The Vilnius system was calibrated in spectral classes and absolute magnitudes by Sviderskienė and Straižys (1971) using individual stars and by Straižys and Jodinskienė (1981) and Straižys, Kurilienė and Jodinskienė (1982b) using the tabulations of M_V for MK types of different spectral and luminosity classes. The calibration of the system in terms of temperatures and surface gravities was done by Straižys, Jodinskienė and Kurilienė (1982a) using the tabulation of T_e and $\log g$ values for different MK types. The preliminary calibration in terms of T_e and $\log g$ using the fluxes of the Kurucz (1979) model atmospheres, made at the same time, was not published, since the energy distributions in the synthetic spectra of model atmospheres were found to be of insufficient accuracy to represent real stars. Additionally, the Kurucz model fluxes were available only for the temperatures higher than 5500 K.

Since then, a new set of model atmospheres was computed by one of the authors (Kurucz, 1991). The calculations of model atmospheres use the new opacities for 58 million lines, additional continuous opacities and improvements in the convection treatment. The new set which was used in the present study includes 410 model atmospheres of solar chemical composition with temperatures between 3500 and 50000 K and $\log g$ between 0.0 and 5.0 dex. In all the models 2 km/s turbulent velocity was taken. We used the newest version of the fluxes for the solar chemical composition recomputed in January, 1993. Fluxes of model atmospheres with metallicities from [Fe/H] = +1.0 to −5.0 dex and other turbulent velocities are also available.

This is the first paper concerning the calibration of the Vilnius photometric system in terms of physical parameters of stars using the new set of Kurucz model fluxes. Here we limit ourselves to temperatures and gravities corresponding to B-type stars of all luminosities and A supergiants.

2. Calculation of colour indices and reddening-free Q-parameters

Synthetic colour indices were calculated by the formula

$$m_1 - m_2 = -2.5 \log \frac{\int F(\lambda)\tau^x(\lambda)S_1(\lambda)d\lambda}{\int F(\lambda)\tau^x(\lambda)S_2(\lambda)d\lambda} + \text{const} \qquad (1)$$

where $F(\lambda)$ are energy fluxes of stellar model atmospheres, $S_1(\lambda)$ and $S_2(\lambda)$ are response functions of bandpasses from Straižys (1992), $\tau(\lambda)$ is the standard transmission function of the unit quantity of interstellar dust from the same source and x is the number of dust units. Colour excesses were calculated as differences between colour indices of the reddened and unreddened ($x = 0$) models. In the case of reddened models, the values of $x = 0.25$, 0.50, 0.75 and 1.00 have been used to obtain the reddening lines and to calculate their slopes in the two-colour diagrams. The last value of x gives $E_{B-V} = 1$ for the hottest stellar models. The Vilnius system bandpasses are relatively narrow and consequently the system has small band-width effect. As a result, the reddening lines in two-colour diagrams are nearly straight lines, i.e. their slope does not depend on the amount of reddening. However, the dependence of the reddening line slope on temperature and surface gravity is significant and must be taken into account calculating the reddening-free Q-parameters.

The constant in (1) was selected so as to make colour indices equal to zero for the model atmosphere with $T_e = 35000$ K and $\log g = 4$. This definition of zero-point makes the synthetic colour indices close to the observed ones.

The colour indices were calculated by two programs. The first one was written by R. Kurucz and it used a 1 Å step in numerical integration. The second one was written by G. Valiauga and it used a 20 Å step which is equal to the step of the model energy fluxes. In both cases the coincidence of calculated colour indices is very good: they differ only by a few thousandths of a magnitude in the spectral regions containing strong lines or intensity jumps. Before integration, the fluxes were transformed from the flux per unit frequency to the flux per unit wavelength form ($F(\lambda) = F(\nu)c/\lambda^2$).

The synthetic colour indices for the model atmospheres with $T_e > 8000$ K are given in Table 2.

Table 2. Synthetic colour indices of the Vilnius system for the hot model atmospheres

T_e	log g	$U-P$	$P-X$	$X-Y$	$Y-Z$	$Z-V$	$V-S$
8000	1.0	1.299	0.615	0.279	0.127	0.074	0.190
8000	1.5	1.284	0.719	0.275	0.105	0.067	0.173
8000	2.0	1.171	0.786	0.302	0.103	0.067	0.172
8000	2.5	1.030	0.827	0.340	0.108	0.070	0.174
8000	3.0	0.885	0.843	0.383	0.116	0.074	0.178
8000	3.5	0.747	0.828	0.429	0.128	0.079	0.184
8000	4.0	0.624	0.781	0.469	0.147	0.087	0.192
8000	4.5	0.515	0.727	0.496	0.162	0.093	0.202
8000	5.0	0.407	0.621	0.508	0.182	0.102	0.233
8250	1.0	1.176	0.543	0.267	0.138	0.077	0.203
8250	1.5	1.247	0.670	0.248	0.103	0.064	0.163
8250	2.0	1.164	0.753	0.265	0.096	0.061	0.156
8250	2.5	1.035	0.809	0.301	0.098	0.063	0.154
8250	3.0	0.893	0.840	0.346	0.104	0.066	0.155
8250	3.5	0.757	0.842	0.393	0.113	0.070	0.157
8250	4.0	0.632	0.812	0.440	0.127	0.076	0.162
8250	4.5	0.521	0.757	0.477	0.146	0.084	0.169
8250	5.0	0.424	0.696	0.502	0.160	0.090	0.176
8500	1.5	1.187	0.618	0.231	0.105	0.063	0.161
8500	2.0	1.141	0.713	0.238	0.092	0.058	0.145
8500	2.5	1.030	0.781	0.268	0.091	0.058	0.140
8500	3.0	0.897	0.824	0.310	0.095	0.060	0.138
8500	3.5	0.762	0.840	0.359	0.103	0.063	0.137
8500	4.0	0.635	0.829	0.410	0.112	0.067	0.137
8500	4.5	0.523	0.784	0.457	0.129	0.074	0.140
8500	5.0	0.426	0.722	0.489	0.147	0.081	0.145
8750	1.5	1.112	0.567	0.219	0.106	0.064	0.164
8750	2.0	1.107	0.668	0.218	0.090	0.056	0.140
8750	2.5	1.017	0.744	0.241	0.086	0.054	0.130
8750	3.0	0.894	0.799	0.279	0.089	0.055	0.125
8750	3.5	0.763	0.830	0.327	0.094	0.057	0.121
8750	4.0	0.636	0.831	0.381	0.102	0.061	0.118
8750	4.5	0.523	0.801	0.434	0.114	0.066	0.117
8750	5.0	0.426	0.744	0.475	0.132	0.073	0.118
9000	1.5	1.025	0.523	0.212	0.107	0.064	0.167
9000	2.0	1.060	0.627	0.205	0.088	0.055	0.138
9000	2.5	0.995	0.708	0.221	0.082	0.052	0.124
9000	3.0	0.884	0.771	0.254	0.083	0.052	0.116
9000	3.5	0.759	0.811	0.300	0.088	0.053	0.109
9000	4.0	0.635	0.824	0.353	0.095	0.056	0.104
9000	4.5	0.522	0.807	0.408	0.104	0.059	0.099
9000	5.0	0.424	0.764	0.461	0.114	0.064	0.096
9250	2.0	1.005	0.589	0.195	0.087	0.055	0.137
9250	2.5	0.964	0.672	0.206	0.079	0.050	0.120
9250	3.0	0.870	0.740	0.234	0.079	0.049	0.110
9250	3.5	0.753	0.788	0.275	0.082	0.050	0.101
9250	4.0	0.632	0.811	0.326	0.088	0.052	0.094
9250	4.5	0.519	0.805	0.383	0.096	0.055	0.086

Table 2 (continued)

T_e	log g	$U-P$	$P-X$	$X-Y$	$Y-Z$	$Z-V$	$V-S$
9250	5.0	0.421	0.770	0.440	0.106	0.059	0.080
9500	2.0	0.943	0.554	0.187	0.085	0.054	0.138
9500	2.5	0.926	0.637	0.194	0.077	0.049	0.118
9500	3.0	0.850	0.707	0.217	0.075	0.047	0.106
9500	3.5	0.744	0.762	0.254	0.077	0.047	0.096
9500	4.0	0.628	0.794	0.303	0.082	0.049	0.086
9500	4.5	0.515	0.798	0.360	0.089	0.051	0.076
9500	5.0	0.416	0.770	0.420	0.099	0.054	0.067
9750	2.0	0.881	0.522	0.181	0.084	0.054	0.138
9750	2.5	0.882	0.605	0.185	0.075	0.049	0.117
9750	3.0	0.823	0.675	0.204	0.072	0.046	0.104
9750	3.5	0.730	0.734	0.237	0.073	0.045	0.092
9750	4.0	0.620	0.773	0.282	0.077	0.046	0.081
9750	4.5	0.510	0.786	0.339	0.084	0.048	0.069
9750	5.0	0.412	0.766	0.399	0.092	0.051	0.058
10000	2.0	0.821	0.494	0.176	0.082	0.054	0.138
10000	2.5	0.835	0.575	0.178	0.072	0.048	0.117
10000	3.0	0.791	0.645	0.194	0.069	0.045	0.102
10000	3.5	0.711	0.705	0.223	0.070	0.044	0.089
10000	4.0	0.610	0.749	0.265	0.073	0.044	0.077
10000	4.5	0.505	0.770	0.318	0.078	0.045	0.064
10000	5.0	0.407	0.759	0.379	0.086	0.048	0.051
10500	2.0	0.714	0.443	0.167	0.079	0.052	0.137
10500	2.5	0.742	0.523	0.167	0.069	0.047	0.115
10500	3.0	0.720	0.591	0.179	0.064	0.044	0.100
10500	3.5	0.663	0.649	0.202	0.064	0.042	0.087
10500	4.0	0.583	0.697	0.236	0.066	0.041	0.073
10500	4.5	0.490	0.728	0.283	0.070	0.042	0.059
10500	5.0	0.396	0.734	0.340	0.076	0.043	0.042
11000	2.5	0.659	0.478	0.158	0.065	0.046	0.113
11000	3.0	0.648	0.543	0.168	0.060	0.042	0.098
11000	3.5	0.607	0.599	0.187	0.059	0.040	0.085
11000	4.0	0.545	0.647	0.216	0.060	0.039	0.071
11000	4.5	0.468	0.683	0.256	0.063	0.039	0.056
11000	5.0	0.384	0.698	0.308	0.068	0.040	0.039
11500	2.5	0.589	0.439	0.150	0.062	0.044	0.111
11500	3.0	0.582	0.501	0.158	0.057	0.041	0.096
11500	3.5	0.551	0.555	0.175	0.055	0.039	0.083
11500	4.0	0.502	0.600	0.201	0.056	0.038	0.070
11500	4.5	0.439	0.636	0.235	0.058	0.037	0.056
11500	5.0	0.367	0.657	0.281	0.062	0.037	0.039
12000	2.5	0.531	0.405	0.143	0.059	0.043	0.108
12000	3.0	0.526	0.464	0.150	0.054	0.040	0.094
12000	3.5	0.499	0.515	0.166	0.052	0.038	0.081
12000	4.0	0.458	0.559	0.189	0.052	0.036	0.069
12000	4.5	0.406	0.593	0.220	0.054	0.035	0.055
12000	5.0	0.346	0.615	0.260	0.057	0.035	0.039
12500	2.5	0.483	0.375	0.136	0.056	0.041	0.104
12500	3.0	0.479	0.432	0.143	0.051	0.038	0.091

Table 2 (continued)

T_e	log g	$U-P$	$P-X$	$X-Y$	$Y-Z$	$Z-V$	$V-S$
12500	3.5	0.454	0.480	0.157	0.049	0.036	0.079
12500	4.0	0.417	0.521	0.179	0.049	0.035	0.067
12500	4.5	0.372	0.554	0.207	0.050	0.034	0.054
12500	5.0	0.321	0.576	0.244	0.052	0.034	0.039
13000	2.5	0.441	0.349	0.130	0.054	0.039	0.100
13000	3.0	0.439	0.404	0.136	0.048	0.037	0.088
13000	3.5	0.416	0.450	0.150	0.046	0.035	0.077
13000	4.0	0.382	0.488	0.170	0.045	0.034	0.066
13000	4.5	0.341	0.519	0.197	0.047	0.033	0.053
13000	5.0	0.296	0.540	0.231	0.049	0.032	0.038
14000	2.0	0.322	0.226	0.127	0.064	0.041	0.113
14000	2.5	0.373	0.303	0.118	0.049	0.036	0.093
14000	3.0	0.374	0.356	0.123	0.043	0.033	0.081
14000	3.5	0.354	0.398	0.136	0.040	0.032	0.071
14000	4.0	0.323	0.433	0.154	0.040	0.031	0.061
14000	4.5	0.287	0.460	0.178	0.041	0.030	0.050
14000	5.0	0.249	0.478	0.209	0.043	0.030	0.036
15000	2.5	0.317	0.263	0.108	0.045	0.033	0.085
15000	3.0	0.324	0.316	0.112	0.038	0.030	0.074
15000	3.5	0.307	0.356	0.123	0.036	0.029	0.065
15000	4.0	0.279	0.387	0.141	0.035	0.028	0.056
15000	4.5	0.246	0.411	0.163	0.036	0.028	0.046
15000	5.0	0.211	0.427	0.191	0.037	0.028	0.034
16000	2.5	0.269	0.225	0.099	0.041	0.030	0.078
16000	3.0	0.281	0.280	0.101	0.034	0.028	0.067
16000	3.5	0.268	0.320	0.112	0.032	0.026	0.058
16000	4.0	0.243	0.349	0.128	0.031	0.026	0.050
16000	4.5	0.213	0.371	0.149	0.031	0.026	0.041
16000	5.0	0.182	0.384	0.175	0.033	0.025	0.030
17000	2.5	0.225	0.188	0.091	0.039	0.028	0.072
17000	3.0	0.245	0.247	0.092	0.030	0.025	0.060
17000	3.5	0.236	0.287	0.102	0.028	0.024	0.052
17000	4.0	0.214	0.316	0.117	0.027	0.023	0.045
17000	4.5	0.187	0.336	0.137	0.027	0.023	0.037
17000	5.0	0.158	0.347	0.161	0.028	0.023	0.027
18000	2.5	0.184	0.152	0.085	0.037	0.026	0.067
18000	3.0	0.212	0.216	0.084	0.027	0.023	0.053
18000	3.5	0.208	0.257	0.092	0.024	0.022	0.046
18000	4.0	0.189	0.285	0.106	0.023	0.021	0.040
18000	4.5	0.164	0.305	0.125	0.024	0.021	0.032
18000	5.0	0.138	0.315	0.149	0.025	0.021	0.023
19000	2.5	0.144	0.116	0.080	0.038	0.025	0.065
19000	3.0	0.182	0.186	0.076	0.025	0.021	0.048
19000	3.5	0.182	0.228	0.083	0.021	0.020	0.040
19000	4.0	0.167	0.257	0.097	0.020	0.019	0.034
19000	4.5	0.145	0.276	0.114	0.020	0.019	0.027
19000	5.0	0.121	0.287	0.137	0.021	0.019	0.019
20000	3.0	0.154	0.158	0.070	0.023	0.020	0.043
20000	3.5	0.159	0.202	0.076	0.018	0.018	0.035

Table 2 (continued)

T_e	log g	$U-P$	$P-X$	$X-Y$	$Y-Z$	$Z-V$	$V-S$
20000	4.0	0.147	0.231	0.088	0.017	0.017	0.029
20000	4.5	0.128	0.250	0.105	0.017	0.017	0.023
20000	5.0	0.106	0.260	0.126	0.018	0.017	0.015
21000	3.0	0.128	0.130	0.064	0.022	0.018	0.040
21000	3.5	0.137	0.177	0.069	0.016	0.016	0.030
21000	4.0	0.129	0.207	0.080	0.014	0.016	0.024
21000	4.5	0.113	0.226	0.095	0.014	0.015	0.018
21000	5.0	0.093	0.236	0.115	0.015	0.015	0.011
22000	3.0	0.105	0.104	0.058	0.021	0.017	0.038
22000	3.5	0.117	0.152	0.062	0.014	0.015	0.027
22000	4.0	0.112	0.183	0.072	0.012	0.014	0.020
22000	4.5	0.098	0.203	0.087	0.011	0.014	0.014
22000	5.0	0.081	0.213	0.106	0.012	0.014	0.007
23000	3.0	0.087	0.082	0.052	0.021	0.015	0.036
23000	3.5	0.099	0.129	0.056	0.013	0.013	0.024
23000	4.0	0.096	0.161	0.066	0.010	0.013	0.016
23000	4.5	0.085	0.182	0.079	0.009	0.012	0.009
23000	5.0	0.070	0.192	0.097	0.009	0.012	0.003
24000	3.0	0.070	0.063	0.045	0.020	0.014	0.033
24000	3.5	0.084	0.109	0.050	0.012	0.012	0.021
24000	4.0	0.082	0.140	0.059	0.009	0.011	0.013
24000	4.5	0.072	0.161	0.072	0.007	0.011	0.006
24000	5.0	0.059	0.172	0.089	0.007	0.011	−0.001
25000	3.0	0.054	0.044	0.040	0.019	0.012	0.030
25000	3.5	0.071	0.092	0.044	0.010	0.010	0.018
25000	4.0	0.069	0.121	0.053	0.007	0.010	0.010
25000	4.5	0.061	0.142	0.065	0.006	0.010	0.003
25000	5.0	0.049	0.153	0.081	0.005	0.009	−0.004
26000	3.0	0.038	0.024	0.036	0.020	0.012	0.031
26000	3.5	0.059	0.078	0.037	0.009	0.009	0.014
26000	4.0	0.058	0.105	0.046	0.006	0.008	0.007
26000	4.5	0.051	0.124	0.059	0.004	0.008	0.000
26000	5.0	0.040	0.135	0.074	0.004	0.008	−0.007
27000	3.5	0.048	0.063	0.030	0.008	0.007	0.010
27000	4.0	0.049	0.091	0.040	0.004	0.007	0.004
27000	4.5	0.041	0.108	0.052	0.003	0.007	−0.002
27000	5.0	0.032	0.118	0.066	0.002	0.007	−0.010
28000	3.5	0.037	0.049	0.024	0.007	0.006	0.008
28000	4.0	0.039	0.078	0.033	0.003	0.005	0.000
28000	4.5	0.033	0.094	0.045	0.001	0.005	−0.005
28000	5.0	0.024	0.103	0.060	0.001	0.006	−0.012
29000	3.5	0.028	0.033	0.019	0.007	0.005	0.007
29000	4.0	0.031	0.065	0.027	0.001	0.004	−0.003
29000	4.5	0.026	0.082	0.039	0.000	0.004	−0.009
29000	5.0	0.017	0.089	0.053	−0.001	0.004	−0.015
30000	3.5	0.019	0.019	0.015	0.008	0.005	0.009
30000	4.0	0.023	0.053	0.021	0.000	0.002	−0.006
30000	4.5	0.018	0.069	0.032	−0.002	0.002	−0.012
30000	5.0	0.011	0.077	0.046	−0.003	0.003	−0.017

Table 2 (continued)

T_e	log g	$U-P$	$P-X$	$X-Y$	$Y-Z$	$Z-V$	$V-S$
31000	3.5	0.013	0.006	0.013	0.008	0.005	0.012
31000	4.0	0.016	0.040	0.015	0.000	0.001	−0.006
31000	4.5	0.012	0.057	0.026	−0.003	0.001	−0.014
31000	5.0	0.005	0.065	0.039	−0.004	0.001	−0.020
32000	4.0	0.010	0.028	0.010	0.000	0.001	−0.006
32000	4.5	0.006	0.046	0.020	−0.004	0.000	−0.015
32000	5.0	0.000	0.053	0.033	−0.005	0.000	−0.021
33000	4.0	0.006	0.017	0.006	0.000	0.000	−0.005
33000	4.5	0.002	0.035	0.014	−0.004	−0.001	−0.016
33000	5.0	−0.004	0.042	0.026	−0.006	−0.001	−0.022
34000	4.0	0.002	0.008	0.003	0.000	0.000	−0.002
34000	4.5	−0.002	0.024	0.009	−0.004	−0.002	−0.015
34000	5.0	−0.007	0.032	0.021	−0.006	−0.002	−0.023
35000	4.0	0.000	0.000	0.000	0.000	0.000	0.000
35000	4.5	−0.005	0.015	0.005	−0.004	−0.002	−0.014
35000	5.0	−0.010	0.023	0.015	−0.007	−0.003	−0.022
37500	4.5	−0.009	−0.002	−0.003	−0.005	−0.003	−0.008
37500	5.0	−0.014	0.004	0.004	−0.007	−0.004	−0.018
40000	4.5	−0.011	−0.012	−0.009	−0.007	−0.003	−0.006
40000	5.0	−0.016	−0.009	−0.004	−0.008	−0.004	−0.014
42500	5.0	−0.017	−0.016	−0.009	−0.010	−0.005	−0.012
45000	5.0	−0.019	−0.022	−0.013	−0.012	−0.006	−0.013
47500	5.0	−0.020	−0.026	−0.016	−0.014	−0.006	−0.013
50000	5.0	−0.021	−0.031	−0.019	−0.016	−0.006	−0.014

Interstellar reddening-free parameters, Q, for classification of stars in two dimensions were calculated from the synthetic colour indices by the equation

$$Q_{123} = (m_1 - m_2) - \frac{E_{m_1-m_2}}{E_{m_2-m_3}}(m_2 - m_3) \, . \qquad (2)$$

Colour excess ratios $E_{m_1-m_2}/E_{m_2-m_3}$ were found for every model individually, to make their Q-parameters really independent of interstellar reddening. For the calculation of Q-parameters the G.V. program with a 20 Å integration step was used.

For two-dimensional quantification of stars the Vilnius photometric system uses the diagram Q_{UPY}, Q_{PYV}. In some cases the parameter Q_{UXY} is useful too. B-type stars of later subclasses can be quantified in the Q_{UPY}, Q_{XYV} diagram. All these Q-parameters for model atmospheres with $T_e > 8000$ K are given in Table 3 together with the corresponding colour excess ratios (for $x = 1.00$).

Table 3. Synthetic reddening-free Q-parameters and colour excess ratios

T_e	log g	Q_{UPY}	$\frac{E_{U-P}}{E_{P-Y}}$	Q_{PYV}	$\frac{E_{P-Y}}{E_{Y-V}}$	Q_{UXY}	$\frac{E_{U-X}}{E_{X-Y}}$	Q_{XYV}	$\frac{E_{X-Y}}{E_{Y-V}}$
8000	1.0	0.904	0.443	0.676	1.081	1.613	1.082	0.128	0.749
8000	1.5	0.829	0.458	0.810	1.072	1.702	1.097	0.147	0.745
8000.	2.0	0.666	0.464	0.905	1.071	1.621	1.114	0.175	0.742
8000	2.5	0.487	0.465	0.977	1.074	1.473	1.130	0.209	0.739
8000	3.0	0.319	0.461	1.022	1.080	1.289	1.145	0.244	0.736
8000	3.5	0.176	0.455	1.031	1.087	1.079	1.157	0.277	0.733
8000	4.0	0.066	0.447	0.994	1.096	0.859	1.165	0.298	0.732
8000	4.5	−0.020	0.438	0.940	1.105	0.662	1.171	0.309	0.732
8000	5.0	−0.072	0.424	0.811	1.118	0.434	1.169	0.299	0.734
8250	1.0	0.821	0.438	0.575	1.089	1.429	1.085	0.105	0.751
8250	1.5	0.829	0.455	0.738	1.076	1.646	1.094	0.123	0.748
8250	2.0	0.691	0.465	0.849	1.072	1.622	1.110	0.148	0.744
8250	2.5	0.516	0.467	0.937	1.073	1.505	1.126	0.182	0.741
8250	3.0	0.342	0.465	1.002	1.078	1.338	1.141	0.220	0.737
8250	3.5	0.190	0.458	1.037	1.084	1.144	1.155	0.259	0.734
8250	4.0	0.068	0.450	1.030	1.093	0.931	1.166	0.291	0.732
8250	4.5	−0.024	0.442	0.981	1.102	0.719	1.172	0.309	0.731
8250	5.0	−0.094	0.432	0.919	1.111	0.529	1.177	0.319	0.731
8500	1.5	0.803	0.452	0.667	1.080	1.553	1.093	0.105	0.749
8500	2.0	0.700	0.464	0.789	1.074	1.591	1.107	0.126	0.746
8500	2.5	0.539	0.468	0.888	1.074	1.510	1.123	0.157	0.743
8500	3.0	0.368	0.467	0.966	1.077	1.368	1.138	0.195	0.739
8500	3.5	0.209	0.461	1.020	1.083	1.189	1.152	0.237	0.735
8500	4.0	0.074	0.453	1.043	1.090	0.986	1.165	0.278	0.732
8500	4.5	−0.028	0.444	1.018	1.099	0.771	1.174	0.309	0.730
8500	5.0	−0.101	0.435	0.958	1.108	0.571	1.179	0.323	0.730
8750	1.5	0.758	0.449	0.603	1.085	1.439	1.095	0.092	0.751
8750	2.0	0.698	0.462	0.729	1.077	1.534	1.106	0.109	0.748
8750	2.5	0.556	0.468	0.834	1.075	1.492	1.120	0.136	0.744
8750	3.0	0.389	0.468	0.923	1.077	1.377	1.135	0.172	0.741
8750	3.5	0.226	0.464	0.993	1.082	1.216	1.149	0.216	0.737
8750	4.0	0.083	0.456	1.035	1.089	1.024	1.163	0.261	0.733
8750	4.5	−0.029	0.446	1.039	1.097	0.814	1.175	0.303	0.730
8750	5.0	−0.107	0.437	0.993	1.106	0.609	1.181	0.326	0.729
9000	1.5	0.696	0.447	0.548	1.090	1.315	1.098	0.083	0.751
9000	2.0	0.678	0.460	0.677	1.080	1.461	1.106	0.097	0.749
9000	2.5	0.561	0.467	0.784	1.077	1.456	1.118	0.121	0.746
9000	3.0	0.404	0.469	0.880	1.078	1.368	1.133	0.154	0.742
9000	3.5	0.242	0.465	0.959	1.082	1.226	1.147	0.196	0.738
9000	4.0	0.096	0.458	1.013	1.088	1.049	1.161	0.242	0.734
9000	4.5	−0.023	0.449	1.037	1.096	0.851	1.173	0.289	0.730
9000	5.0	−0.113	0.439	1.029	1.104	0.643	1.183	0.332	0.727
9250	2.0	0.646	0.457	0.630	1.084	1.378	1.107	0.089	0.750
9250	2.5	0.555	0.465	0.738	1.080	1.406	1.118	0.109	0.747
9250	3.0	0.414	0.468	0.836	1.079	1.345	1.131	0.139	0.744
9250	3.5	0.258	0.466	0.920	1.082	1.227	1.144	0.177	0.740
9250	4.0	0.110	0.459	0.986	1.088	1.066	1.158	0.223	0.736

Table 3 (continued)

T_e	log g	Q_{UPY}	$\frac{E_{U-P}}{E_{P-Y}}$	Q_{PYV}	$\frac{E_{P-Y}}{E_{Y-V}}$	Q_{UXY}	$\frac{E_{U-X}}{E_{X-Y}}$	Q_{XYV}	$\frac{E_{X-Y}}{E_{Y-V}}$
9250	4.5	−0.016	0.450	1.023	1.095	0.876	1.171	0.273	0.731
9250	5.0	−0.112	0.440	1.028	1.103	0 670	1.183	0.321	0.728
9500	2.0	0.606	0.455	0.589	1.088	1.289	1.109	0.083	0.750
9500	2.5	0.541	0.463	0.695	1.082	1.346	1.118	0.100	0.748
9500	3.0	0.418	0.467	0.792	1.081	1.312	1.130	0.126	0.745
9500	3.5	0.270	0.466	0.881	1.083	1.215	1.143	0.162	0.741
9500	4.0	0.122	0.461	0.955	1.088	1.071	1.156	0.207	0.737
9500	4.5	−0.008	0.452	1.004	1.095	0.892	1.170	0.257	0.732
9500	5.0	−0.109	0.442	1.021	1.102	0.689	1.182	0.309	0.728
9750	2.0	0.563	0.453	0.553	1.091	1.202	1.112	0.078	0.751
9750	2.5	0 517	0.461	0.656	1.085	1.279	1.119	0.093	0.748
9750	3.0	0.413	0.466	0.752	1.083	1.267	1.129	0.116	0.746
9750	3.5	0.277	0.466	0.842	1.084	1.193	1.141	0.149	0.742
9750	4.0	0.133	0.461	0.921	1.088	1 067	1.154	0.191	0.738
9750	4.5	0.001	0.453	0.980	1.095	0.900	1.168	0.242	0.734
9750	5.0	−0.104	0.443	1.008	1.102	0.707	1.180	0.295	0.729
10000	2.0	0.519	0.451	0.521	1.094	1.119	1.114	0.074	0.751
10000	2.5	0.489	0.459	0.622	1.088	1.211	1.120	0.088	0.749
10000	3.0	0.402	0.464	0.715	1.086	1.217	1.129	0.109	0.746
10000	3.5	0.279	0.465	0.804	1.086	1.161	1 140	0.139	0.743
10000	4.0	0.142	0.461	0.887	1.089	1.054	1.153	0.178	0.739
10000	4.5	0.011	0.454	0.953	1.095	0.903	1.166	0.227	0.735
10000	5.0	−0.098	0.444	0.990	1.102	0.720	1.179	0.281	0.730
10500	2.0	0.441	0.447	0.466	1.100	0.970	1.119	0.068	0.752
10500	2.5	0 428	0.456	0.564	1.094	1.079	1.124	0.080	0.750
10500	3.0	0.366	0.461	0.652	1.090	1.108	1.131	0.098	0.747
10500	3.5	0.270	0.462	0.736	1.090	1.082	1.140	0.123	0.745
10500	4.0	0.154	0.460	0.816	1.092	1.009	1.150	0.157	0.741
10500	4.5	0.031	0.454	0.889	1.096	0.890	1.162	0.200	0.737
10500	5.0	−0.082	0.445	0.943	1.102	0.730	1.175	0.253	0.733
11000	2.5	0.372	0.452	0.514	1.099	0.960	1.127	0.074	0.750
11000	3.0	0.323	0.457	0.598	1.095	1.001	1.133	0.091	0.748
11000	3.5	0.246	0.459	0.677	1.094	0.993	1.140	0.113	0.746
11000	4.0	0.150	0.458	0.754	1.095	0.944	1.149	0.142	0.743
11000	4.5	0.043	0.453	0.826	1.098	0.854	1.160	0.180	0.739
11000	5.0	−0.065	0.446	0.887	1.103	0.721	1.171	0.229	0.735
11500	2.5	0 325	0.449	0 471	1.103	0.858	1.129	0.070	0.751
11500	3.0	0.283	0.453	0.551	1.100	0.903	1.135	0.085	0.749
11500	3.5	0.218	0.455	0.626	1.098	0.905	1.141	0.105	0.746
11500	4.0	0.137	0.455	0.699	1.099	0.871	1.149	0.131	0.744
11500	4.5	0.046	0.451	0.767	1.101	0.803	1.158	0.165	0.741
11500	5.0	−0.050	0.445	0.829	1.105	0.696	1.169	0.208	0.737
12000.	2.5	0.287	0.446	0.435	1.107	0.774	1.132	0.066	0.751
12000	3.0	0.249	0.450	0.511	1.103	0.819	1.136	0.080	0.749
12000	3.5	0.191	0.452	0.582	1.102	0.825	1.142	0.099	0.747
12000	4.0	0.120	0.452	0.650	1.102	0.799	1.149	0.123	0.745
12000	4.5	0.041	0.449	0.715	1.104	0.745	1.157	0.154	0.742

Table 3 (continued)

T_e	log g	Q_{UPY}	$\frac{E_{U-P}}{E_{P-Y}}$	Q_{PYV}	$\frac{E_{P-Y}}{E_{Y-V}}$	Q_{UXY}	$\frac{E_{U-X}}{E_{X-Y}}$	Q_{XYV}	$\frac{E_{X-Y}}{E_{Y-V}}$
12000	5.0	−0.042	0.444	0.774	1.108	0.657	1.167	0.193	0.738
12500	2.5	0.256	0.444	0.403	1.110	0.704	1.134	0.063	0.751
12500	3.0	0.221	0.448	0.476	1.107	0.748	1.138	0.076	0.749
12500	3.5	0.168	0.449	0.543	1.105	0.755	1.143	0.094	0.748
12500	4.0	0.103	0.449	0.608	1.106	0.733	1.150	0.116	0.745
12500	4.5	0.032	0.446	0.669	1.107	0.687	1.157	0.145	0.742
12500	5.0	−0.041	0.442	0.725	1.110	0.613	1.165	0.181	0.739
13000	2.5	0.230	0.442	0.376	1.112	0.643	1.135	0.060	0.751
13000	3.0	0.198	0.446	0.446	1.109	0.688	1.139	0.072	0.750
13000	3.5	0.148	0.447	0.510	1.108	0.694	1.144	0.089	0.748
13000	4.0	0.088	0.446	0.570	1.109	0.675	1.150	0.111	0.746
13000	4.5	0.023	0.444	0.628	1.110	0.633	1.157	0.138	0.743
13000	5.0	−0.043	0.440	0.681	1.113	0.567	1.165	0.171	0.740
14000	2.0	0.171	0.431	0.235	1.125	0.404	1.136	0.048	0.753
14000	2.5	0.188	0.439	0.327	1.117	0.542	1.138	0.055	0.752
14000	3.0	0.162	0.442	0.395	1.114	0.590	1.141	0.066	0.750
14000	3.5	0.118	0.443	0.453	1.113	0.597	1.146	0.081	0.749
14000	4.0	0.064	0.442	0.508	1.114	0.579	1.151	0.101	0.747
14000	4.5	0.007	0.440	0.559	1.115	0.541	1.157	0.125	0.744
14000	5.0	−0.051	0.436	0.606	1.117	0.484	1.164	0.155	0.741
15000	2.5	0.156	0.436	0.284	1.121	0.457	1.140	0.050	0.752
15000	3.0	0.136	0.439	0.351	1.118	0.512	1.143	0.060	0.751
15000	3.5	0.096	0.440	0.407	1.117	0.521	1.147	0.075	0.749
15000	4.0	0.047	0.439	0.457	1.117	0.504	1.152	0.093	0.747
15000	4.5	−0.005	0.437	0.503	1.119	0.468	1.157	0.115	0.745
15000	5.0	−0.056	0.433	0.545	1.121	0.416	1.164	0.143	0.743
16000	2.5	0.129	0.433	0.243	1.125	0.381	1.142	0.045	0.753
16000	3.0	0.115	0.437	0.313	1.121	0.446	1.144	0.055	0.751
16000	3.5	0.079	0.438	0.367	1.120	0.459	1.148	0.069	0.750
16000	4.0	0.035	0.437	0.414	1.120	0.445	1.152	0.086	0.748
16000	4.5	−0.013	0.434	0.456	1.122	0.411	1.157	0.107	0.746
16000	5.0	−0.059	0.431	0.494	1.124	0.361	1.163	0.132	0.743
17000	2.5	0.105	0.430	0.204	1.128	0.309	1.143	0.041	0.753
17000	3.0	0.098	0.434	0.277	1.124	0.387	1.145	0.050	0.752
17000	3.5	0.067	0.436	0.331	1.123	0.406	1.149	0.063	0.750
17000	4.0	0.026	0.435	0.376	1.123	0.395	1.153	0.079	0.748
17000	4.5	−0.018	0.432	0.416	1.124	0.364	1.157	0.099	0.747
17000	5.0	−0.061	0.429	0.451	1.126	0.317	1.163	0.123	0.744
18000	2.5	0.083	0.427	0.165	1.132	0.238	1.144	0.037	0.753
18000	3.0	0.083	0.432	0.243	1.127	0.333	1.146	0.046	0.752
18000	3.5	0.056	0.434	0.297	1.125	0.358	1.149	0.058	0.751
18000	4.0	0.019	0.433	0.342	1.125	0.351	1.153	0.073	0.749
18000	4.5	−0.021	0.431	0.380	1.127	0.324	1.157	0.092	0.747
18000	5.0	−0.061	0.428	0.413	1.128	0.281	1.162	0.115	0.745
19000	2.5	0.061	0.423	0.124	1.136	0.169	1.144	0.032	0.754
19000	3.0	0.069	0.430	0.211	1.129	0.281	1.146	0.042	0.752
19000	3.5	0.048	0.432	0.266	1.127	0.315	1.149	0.053	0.751

Table 3 (continued)

T_e	log g	Q_{UPY}	$\frac{E_{U-P}}{E_{P-Y}}$	Q_{PYV}	$\frac{E_{P-Y}}{E_{Y-V}}$	Q_{UXY}	$\frac{E_{U-X}}{E_{X-Y}}$	Q_{XYV}	$\frac{E_{X-Y}}{E_{Y-V}}$
19000	4.0	0.015	0.431	0.310	1.127	0.313	1.153	0.067	0.749
19000	4.5	−0.023	0.429	0.347	1.128	0.289	1.157	0.085	0.748
19000	5.0	−0.060	0.426	0.378	1.130	0.249	1.162	0.107	0.746
20000	3.0	0.057	0.428	0.179	1.132	0.231	1.147	0.038	0.753
20000	3.5	0.040	0.430	0.237	1.129	0.274	1.150	0.049	0.751
20000	4.0	0.010	0.430	0.280	1.129	0.277	1.153	0.062	0.750
20000	4.5	−0.024	0.428	0.316	1.130	0.257	1.157	0.079	0.748
20000	5.0	−0.058	0.425	0.347	1.132	0.220	1.161	0.100	0.746
21000	3.0	0.046	0.426	0.148	1.134	0.184	1.147	0.034	0.753
21000	3.5	0.032	0.428	0.209	1.131	0.235	1.150	0.045	0.752
21000	4.0	0.006	0.428	0.253	1.131	0.244	1.153	0.057	0.750
21000	4.5	−0.024	0.427	0.288	1.132	0.228	1.157	0.073	0.749
21000	5.0	−0.056	0.424	0.317	1.133	0.195	1.161	0.093	0.747
22000	3.0	0.037	0.423	0.119	1.137	0.143	1.147	0.029	0.754
22000	3.5	0.026	0.427	0.181	1.133	0.198	1.150	0.040	0.752
22000	4.0	0.003	0.427	0.227	1.133	0.212	1.153	0.053	0.751
22000	4.5	−0.025	0.425	0.262	1.133	0.201	1.156	0.068	0.749
22000	5.0	−0.054	0.423	0.290	1.134	0.171	1.160	0.087	0.747
23000	3.0	0.030	0.422	0.093	1.139	0.109	1.147	0.025	0.754
23000	3.5	0.021	0.425	0.155	1.135	0.164	1.150	0.036	0.753
23000	4.0	0.000	0.426	0.201	1.134	0.182	1.153	0.049	0.751
23000	4.5	−0.026	0.424	0.236	1.135	0.175	1.156	0.063	0.750
23000	5.0	−0.053	0.422	0.265	1.136	0.149	1.160	0.081	0.748
24000	3.0	0.025	0.420	0.070	1.140	0.081	1.147	0.020	0.754
24000	3.5	0.017	0.424	0.132	1.137	0.136	1.149	0.032	0.753
24000	4.0	−0.003	0.424	0.177	1.136	0.154	1.152	0.044	0.752
24000	4.5	−0.027	0.423	0.212	1.136	0.150	1.156	0.058	0.750
24000	5.0	−0.051	0.422	0.240	1.137	0.128	1.160	0.075	0.748
25000	3.0	0.019	0.419	0.048	1.142	0.053	1.147	0.016	0.755
25000	3.5	0.014	0.422	0.112	1.138	0.113	1.149	0.028	0.753
25000	4.0	−0.004	0.423	0.155	1.137	0.130	1.152	0.040	0.752
25000	4.5	−0.027	0.423	0.189	1.137	0.127	1.155	0.054	0.750
25000	5.0	−0.050	0.421	0.217	1.138	0.108	1.159	0.070	0.749
26000	3.0	0.013	0.417	0.022	1.144	0.020	1.147	0.011	0.755
26000	3.5	0.011	0.422	0.094	1.139	0.094	1.149	0.024	0.754
26000	4.0	−0.006	0.422	0.136	1.138	0.110	1.152	0.036	0.752
26000	4.5	−0.026	0.422	0.168	1.138	0.107	1.155	0.049	0.751
26000	5.0	−0.048	0.420	0.195	1.139	0.090	1.159	0.065	0.749
27000	3.5	0.009	0.421	0.077	1.140	0.077	1.149	0.019	0.754
27000	4.0	−0.007	0.422	0.119	1.139	0.094	1.152	0.032	0.753
27000	4.5	−0.026	0.421	0.149	1.139	0.090	1.155	0.045	0.751
27000	5.0	−0.046	0.420	0.175	1.140	0.073	1.158	0.060	0.750
28000	3.5	0.007	0.420	0.058	1.142	0.058	1.149	0.015	0.754
28000	4.0	−0.008	0.421	0.103	1.140	0.079	1.152	0.028	0.753
28000	4.5	−0.026	0.420	0.132	1.140	0.075	1.155	0.041	0.752
28000	5.0	−0.044	0.419	0.156	1.141	0.058	1.158	0.055	0.750
29000	3.5	0.006	0.419	0.039	1.143	0.039	1.149	0.010	0.754

Table 3 (continued)

T_e	log g	Q_{UPY}	$\frac{E_{U-P}}{E_{P-Y}}$	Q_{PYV}	$\frac{E_{P-Y}}{E_{Y-V}}$	Q_{UXY}	$\frac{E_{U-X}}{E_{X-Y}}$	Q_{XYV}	$\frac{E_{X-Y}}{E_{Y-V}}$
29000	4.0	−0.008	0.420	0.087	1.141	0.065	1.152	0.023	0.753
29000	4.5	−0.025	0.420	0.117	1.141	0.062	1.154	0.036	0.752
29000	5.0	−0.042	0.419	0.138	1.141	0.046	1.157	0.050	0.750
30000	3.5	0.005	0.417	0.020	1.144	0.020	1.149	0.006	0.755
30000	4.0	−0.008	0.420	0.070	1.142	0.052	1.152	0.019	0.753
30000	4.5	−0.024	0.419	0.101	1.142	0.051	1.154	0.032	0.752
30000	5.0	−0.040	0.418	0.123	1.142	0.034	1.157	0.046	0.751
31000	3.5	0.005	0.416	0.004	1.145	0.004	1.148	0.003	0.755
31000	4.0	−0.007	0.419	0.053	1.143	0.038	1.151	0.014	0.754
31000	4.5	−0.023	0.419	0.086	1.142	0.040	1.154	0.027	0.752
31000	5.0	−0.038	0.418	0.107	1.143	0.025	1.157	0.041	0.751
32000	4.0	−0.006	0.418	0.037	1.144	0.026	1.151	0.010	0.754
32000	4.5	−0.021	0.418	0.070	1.143	0.029	1.154	0.023	0.753
32000	5.0	−0.036	0.417	0.092	1.143	0.016	1.156	0.036	0.751
33000	4.0	−0.004	0.417	0.023	1.145	0.016	1.150	0.006	0.754
33000	4.5	−0.019	0.418	0.055	1.144	0.020	1.153	0.018	0.753
33000	5.0	−0.033	0.417	0.076	1.144	0.008	1.156	0.031	0.752
34000	4.0	−0.002	0.417	0.010	1.145	0.007	1.150	0.002	0.755
34000	4.5	−0.016	0.417	0.040	1.144	0.012	1.153	0.014	0.753
34000	5.0	−0.029	0.417	0.062	1.144	0.001	1.155	0.027	0.752
31000	3.5	0.005	0.416	0.004	1.145	0.004	1.148	0.003	0.755
31000	4.0	−0.007	0.419	0.053	1.143	0.038	1.151	0.014	0.754
31000	4.5	−0.023	0.419	0.086	1.142	0.040	1.154	0.027	0.752
31000	5.0	−0.038	0.418	0.107	1.143	0.025	1.157	0.041	0.751
32000	4.0	−0.006	0.418	0.037	1.144	0.026	1.151	0.010	0.754
32000	4.5	−0.021	0.418	0.070	1.143	0.029	1.154	0.023	0.753
32000	5.0	−0.036	0.417	0.092	1.143	0.016	1.156	0.036	0.751
33000	4.0	−0.004	0.417	0.023	1.145	0.016	1.150	0.006	0.754
33000	4.5	−0.019	0.418	0.055	1.144	0.020	1.153	0.018	0.753
33000	5.0	−0.033	0.417	0.076	1.144	0.008	1.156	0.031	0.752
34000	4.0	−0.002	0.417	0.010	1.145	0.007	1.150	0.002	0.755
34000	4.5	−0.016	0.417	0.040	1.144	0.012	1.153	0.014	0.753
34000	5.0	−0.029	0.417	0.062	1.144	0.001	1.155	0.027	0.752
35000	4.0	0.000	0.416	0.000	1.146	0.000	1.150	0.000	0.755
35000	4.5	−0.013	0.417	0.027	1.145	0.005	1.152	0.010	0.754
35000	5.0	−0.026	0.416	0.048	1.145	−0.005	1.155	0.022	0.753
37500	4.5	−0.006	0.416	0.003	1.146	−0.007	1.151	0.002	0.754
37500	5.0	−0.017	0.416	0.019	1.146	−0.015	1.153	0.012	0.753
40000	4.5	−0.003	0.415	−0.009	1.146	−0.012	1.151	−0.001	0.754
40000	5.0	−0.010	0.415	0.001	1.146	−0.020	1.152	0.005	0.754
42500	5.0	−0.007	0.415	−0.009	1.147	−0.023	1.152	0.002	0.754
45000	5.0	−0.004	0.415	−0.015	1.147	−0.025	1.152	0.000	0.754
47500	5.0	−0.002	0.415	−0.020	1.147	−0.028	1.152	−0.001	0.754
50000	5.0	−0.001	0.415	−0.024	1.147	−0.030	1.152	−0.002	0.754

3. The Q_{UPY}, Q_{PYV} diagram for determination of effective temperatures and surface gravities

The Q_{UPY}, Q_{PYV} diagram for quantification of B-type stars in terms of the effective temperatures and surface gravities is shown in Fig. 1. For estimation of the accuracy of the calibration, we have used some comparisons with the observational scales of T_e and $\log g$.

The first method of comparison is based on the use of tabulations of the effective temperatures and surface gravities for stars of different MK types. Such tabulations usually are based on careful and critical analysis of the existing determinations of physical parameters of stars.

For such a comparison we have used the tabulation of T_e and $\log g$ for different MK types published by Straižys and Kurilienė (1981) and repeated in the Straižys (1992) monograph. Their T_e values were obtained by averaging observational results of many authors. After that, the values of $\log g$ were derived by using these T_e values together with independent luminosity tabulation and the masses of stars estimated from their evolutionary tracks in the HR diagram. These values of T_e and $\log g$ can be compared with T_e and $\log g$ determined from Fig. 1 using the Q-parameters calculated for the intrinsic colour indices of stars of corresponding spectral and luminosity classes taken from Straižys (1992).

The Kurucz grid of B-type model atmospheres is not given for $\log g < 2.5$ dex; consequently, the physical parameters cannot be determined by interpolation for B5–A2 type stars of luminosity class Ia, which, according to Straižys and Kurilienė (1981), have their $\log g$ values from 2.2 to 1.7 dex. However, for estimation of $\log g$ it is possible to use extrapolation of the $\log g$ isoline net in Fig. 1. This cannot be done for the T_e isolines, since they show considerable bending in the region of B-supergiants.

Both sets of T_e and $\log g$ are intercompared in Figs. 2 and 3. Although there is a general agreement in the scales, a number of systematic effects are observable. In Fig. 2 the Kurucz model atmospheres of B2–B5 luminosity V-IV-III stars show T_e which are by 1500–2500 K cooler than T_e in the Straižys and Kurilienė scale. In Fig. 3 the Kurucz models of B1–B3 luminosity V-IV-III stars show $\log g$ values by 0.3–0.6 dex lower. However, these systematic differences do not mean that the model atmosphere fluxes are wrong. These discrepancies can be also caused by systematic errors in the intrinsic colour indices which in the case of B-type stars are based on

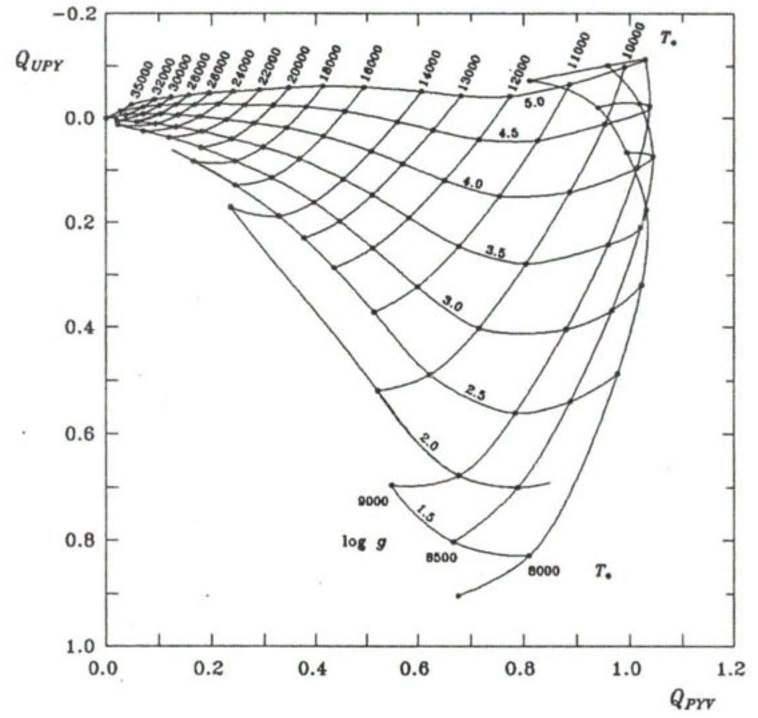

Fig. 1. The Q_{UPY}, Q_{PYV} diagram calibrated in effective temperatures and surface gravities.

relatively small number of stars. The scale of T_e and $\log g$, tabulated by Straižys and Kurilienė, also may contain some systematic errors.

Another method of verification of the calibration is based on a set of B-type stars of different luminosities with their temperatures and gravities determined by independent methods. The [Fe/H] catalogue of Cayrel de Strobel et al. (1992), which contains also the T_e and $\log g$ data, shows that there are only 20 B–A0 type stars in it with the Vilnius photometry. In Figs. 4 and 5 we compare T_e and $\log g$ from the Cayrel de Strobel et al. catalogue with the corresponding data obtained from the observed colour indices in the Vilnius system, taken from the general catalogue (Straižys and Kazlauskas, 1993), and the calibrated diagram in Fig. 1. One can see a very close coincidence of the effective temperatures determined by the completely independent methods. The standard deviation $\sigma(\log T_e)$ is of the order of ± 0.02 dex. The coincidence of the $\log g$ values is of the

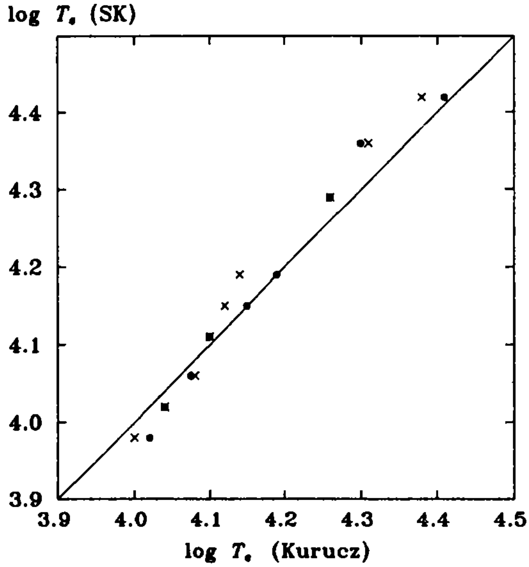

Fig. 2. Comparison of effective temperatures from Fig. 1 and from tabulation by Straižys and Kurilienė (1981).

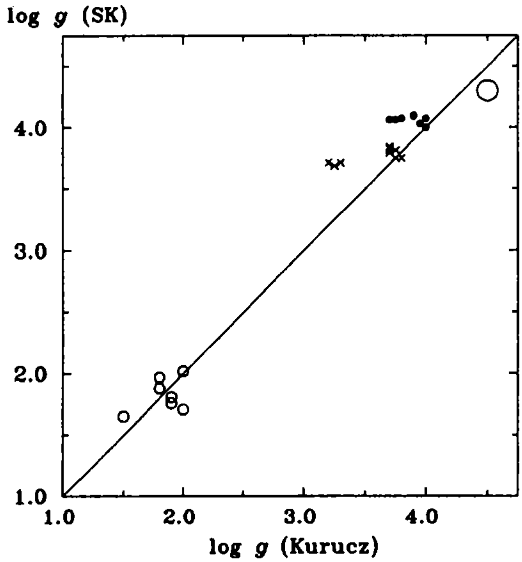

Fig. 3. Comparison of surface gravities from Fig. 1 and from tabulation by Straižys and Kurilienė (1981). The circle is for the ZAMS stars.

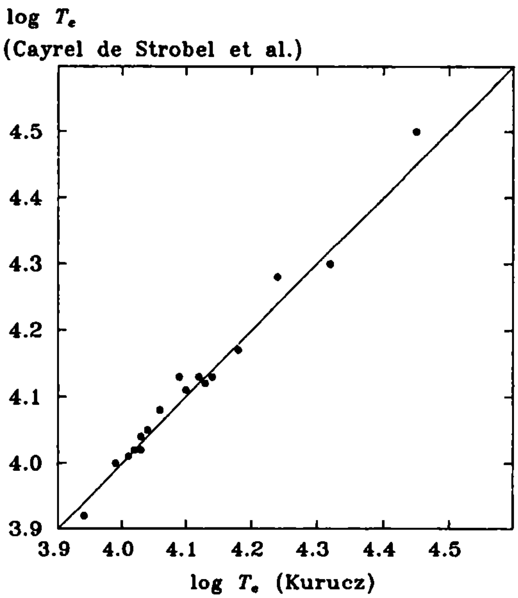

Fig. 4. Comparison of effective temperatures from Fig. 1 and from Cayrel de Strobel et al. (1992).

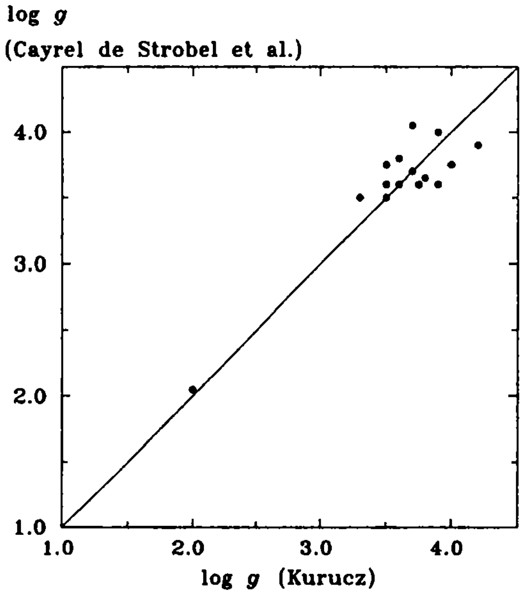

Fig. 5. Comparison of surface gravities from Fig. 1 and from Cayrel de Strobel et al. (1992).

order of ±0.20 dex. For more detailed comparison of both sets of $\log g$ determinations we need more common stars, especially of high luminosities.

Another source of a homogeneous set of spectroscopic $\log g$ values are papers published by Kopylov (1970) and Gulyaev et al. (1987), astronomers of the Special Astrophysical Observatory. The first paper contains $\log g$ values of 14 B8–F2 supergiants determined from the widths and strengths of the Balmer lines. The second paper contains 57 B and A stars for which $\log g$ values were determined by the same method plus by the shape of the Balmer jump. Among stars of these papers we find 32 stars measured in the Vilnius system. For all these stars spectroscopic effective temperatures are also given. Comparison of the photometric and spectroscopic $\log T_e$ and $\log g$ values is shown in Figs. 6 and 7. The correspondence of both sets of T_e values shows the standard deviation of ±0.055 dex, which is twice larger than in Fig. 4. A systematic deviation of T_e at B5 ($\log T_e$ between 4.17 and 4.26 dex) is present.

In the case of $\log g$ (Fig. 7), the scatter of stars is also larger (±0.32 dex) than in Fig. 5. Among higher luminosity stars, very good agreement of $\log g$ is found for γ Lyr (B9 III), γ UMi (A3 II-III) and η Leo (A0 Ib). The stars α Cyg (A2 Ia) and β Ori (B8 Ia) are also near the 45° line but for determination of their photometric $\log g$ we have used some extrapolation of the net.

4. The zero-age main sequence in the Q_{UPY}, Q_{PYV} diagram

One more possibility to check the validity of the model atmosphere calibration of the Q_{UPY}, Q_{PYV} diagram concerns the zero-age main sequence. The comparison of its position in the diagram with respect to the $\log g$ isolines can give us information how the model atmospheres correspond to the real stars in the high gravity range.

For the determination of the zero-age main sequence in the diagram, we used observations of 82 B-type stars in the Ori OB1 association Orion Belt subgroup (Warren and Hesser, 1977). These stars have been observed in the Vilnius system by K. Černis and kindly provided to us before publication. Fig. 8 shows the plot of these stars in the Q_{UPY}, Q_{PYV} diagram together with $\log g$ isolines for 4.0, 4.5 and 5.0 dex. One can see that the majority of points are grouping around the isoline with $\log g = 4.5$. This is in close agreement with the Straižys and Kurilienė (1981) tabulation where the values $\log g = 4.3$ dex are given for the B-type ZAMS stars.

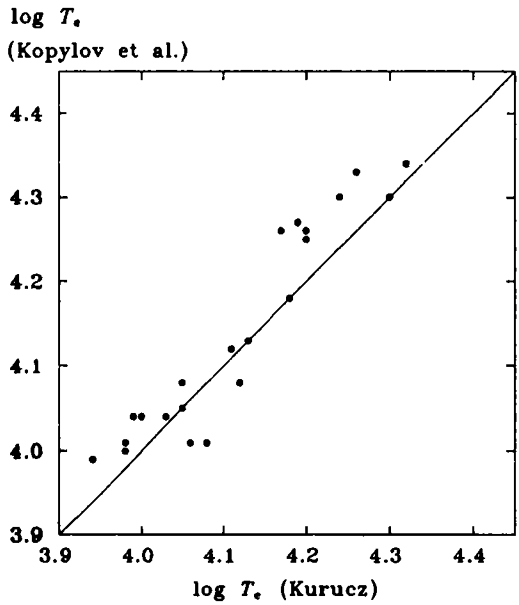

Fig. 6. Comparison of effective temperatures from Fig. 1 and from Kopylov (1970) and Gulyaev et al. (1987).

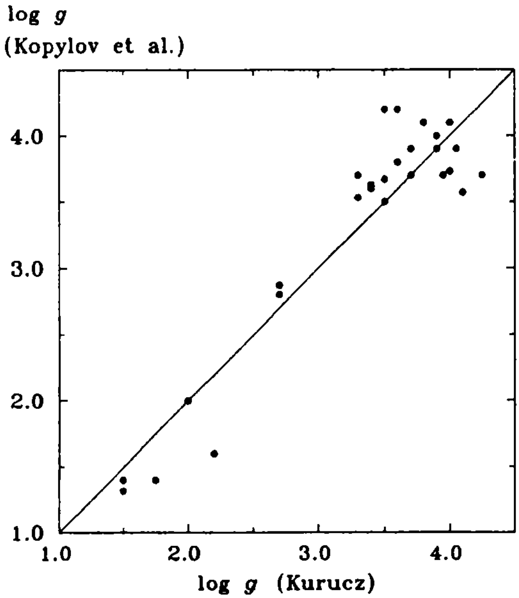

Fig. 7. Comparison of surface gravities from Fig. 1 and from Kopylov (1970) and Gulyaev et al. (1987).

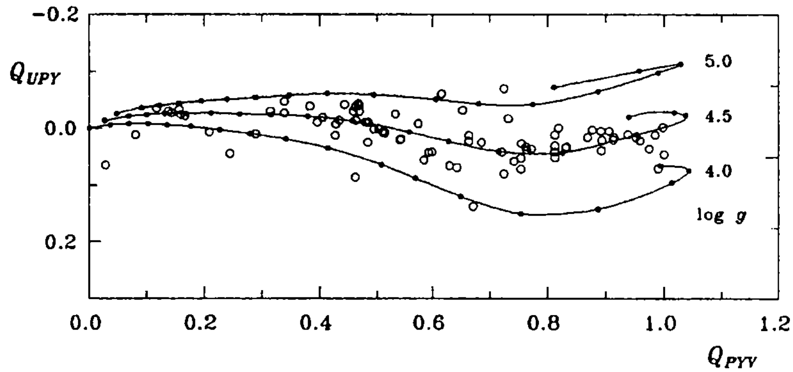

Fig. 8. The zero-age main sequence of Ori OB1 association in the Q_{UPY}, Q_{PYV} diagram. The isolines of $\log g$ for 4.0, 4.5 and 5.0 are plotted.

5. Possible ambiguity of the calibration

As it was noticed by Kurucz (1991), one must not expect that the available model atmospheres represent the real stars exactly. There are physical and composition factors, affecting the synthetic spectra, which are not taken into account in calculations of the models and their fluxes. The main parameters of the present set of model atmospheres are the effective temperature, surface gravity, metallicity and turbulent velocity. Some other effects are important in the atmospheres of hot stars: variations of helium abundance due to diffusion in the atmosphere, variations of the CNO group abundance in different stages of nuclear and mixing evolution, rotational effects due to variations of T_e and $\log g$ along the surface, etc.

Consequently, we do not expect that the calibration of a photometric system with a grid of models will give us exact T_e and $\log g$ for any star measured photometrically. A real star can be different from the photometrically closest model by abundances of elements of the iron group, CNO group or helium, by rotational velocity, by the aspect of view or by turbulent velocity. When all these parameters are unknown, we are able to determine only statistically correct values of T_e and $\log g$. Their accuracy can be estimated by making special model atmosphere calculations, changing values of all possible factors influencing the structure of the atmosphere and the synthetic spectrum.

In this paper, we are able to estimate only the effects of the turbulent velocity and of the scaled solar metallicity. We have calculated Q_{UPY} and Q_{PYV} parameters for V_t = 4 km/s and compared the results with Table 3 data calculated for 2 km/s. In the temperature range >10000 K, the differences are sufficiently small: $|\Delta Q_{UPY}| < 0.005$ mag and $|\Delta Q_{PYV}| < 0.007$ mag. Thus, in the photometric classification of B-type stars, the turbulence differences may be neglected.

The dependence of the Q-parameters on metallicity is much more complicated. For $\log g$ = 4.0 dex, the parameter Q_{UPY} at $T_e > 10000$ K is relatively insensitive to [Fe/H]: its variations do not exceed ±0.01 mag. For lower gravities, its variations with metallicity are larger: at $\log g$ = 2.5 dex and T_e between 12000 and 20000 K, difference ΔQ_{UPY} between the metallicities [Fe/H] = 0.0 dex and –3.0 dex is 0.03 mag. More sensitive to metallicity is the parameter Q_{PYV}. With decreasing metallicity from 0.0 dex to –3.0 dex, Q_{PYV} increases by 0.04–0.06 mag.

Fortunately, most of B-type stars of Population I in the Galaxy are young objects and their metallicity is close to solar. Thus, for them, metallicity effects on Q_{UPY} and Q_{PYV}, exceeding ±0.01 mag, are not expected.

6. Conclusions

The calibration of the colour indices $U-P$, $P-X$, $X-Y$, $Y-Z$, $Z-V$ and $V-S$ and the reddening-free parameters Q_{UPY}, Q_{PYV}, Q_{UXY} and Q_{XYV} of the Vilnius system for early-type stars in terms of the effective temperatures and surface gravities is done, using the synthetic spectra of the newest Kurucz model atmospheres. The calibration of the basic reddening-free diagram Q_{UPY}, Q_{PYV} for quantification of B-type stars of all luminosities as well as of A-supergiants, is verified using the spectroscopic $\log T_e$ and $\log g$ data determined in high-dispersion studies. The photometric values of $\log T_e$ coincide with the spectroscopic data from Cayrel de Strobel et al. (1992) compilation within ±0.02 dex and with the Kopylov (1970) and Gulyaev et al. (1987) data within ±0.055 dex. For $\log g$, the coincidence is ±0.2 dex and ±0.3 dex, respectively.

The new calibration can be used for determination of T_e and $\log g$ of B-type stars of all luminosities and A-supergiants, replacing the earlier preliminary calibration by Straižys et al. (1982a) based on the average values of T_e and $\log g$ for different spectral and luminosity classes.

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