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INTRINSIC COLOR INDICES IN THE WBVR SYSTEM

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Abstract. Intrinsic color indices of stars of different spectral and luminosity classes in the system *WBVR* are determined. The system is a variant of the Johnson's *UBVR* system with the revised ultraviolet passband. The intrinsic color indices of both systems are intercompared.

Key words: astrophotometric systems: intrinsic colors – methods: data analysis – stars: fundamental parameters

1. Introduction

It is well known that the ultraviolet *U–B* index has been ill-defined during the introduction of the *UBV* system. The main shortcomings of the ultraviolet magnitude *U* and the index *U–B* have been described several times by one of the authors (Straižys 1963, 1973, 1977, 1983, 1992; Ažusienis and Straižys 1966):

(1) *U–B* has been reduced to outside the atmosphere neglecting the dependence of the extinction coefficient on spectral type, luminosity and interstellar reddening,

(2) the standard *U–B* system is a combination of two systems with different response functions of the ultraviolet passband,

(3) it is not possible to restore the accurate response function of the *U* passband and this limits the accuracy with which one can obtain the synthetic color indices, color excesses, slopes of the reddening lines, ratios of interstellar extinction to reddening, etc.

(4) the *U* passband includes the rising part of the Balmer jump, making the *U* magnitude a bad criterion of intensity of the spectrum to the short wavelengths from the Balmer jump,

(5) the ultraviolet filter which has been used to realize the U passband had a considerable leak in the red part of the spectrum; its account for the reddest or heavily reddened stars is of low accuracy,

(6) there are considerable systematic differences between U–B determined by various authors due to transformation difficulties from instrumental systems to the ill-defined standard system.

The revised ultraviolet magnitude without the listed shortcomings, designated W, has been proposed by Straižys (1973). Its response function is completely beyond the Balmer jump and has no red leak. The *WBVR* system has been verified observationally by Meištas et al. (1975) using the method of reduction to outside the atmosphere proposed by Zdanavičius (1975). The method gives the extra-atmospheric W–B values with the accuracy of ± 0.01 mag. The description of the method in English is given by Straižys (1992).

At the start of the eighties the system *WBVR* was realized by Khaliullin et al. (1985) at the Tien-Shan Observatory of the Sternberg Astronomical Institute at Moscow. The result was the Catalogue of the *WBVR* photometry of 13586 stars down to 7.2 mag of the Northern sky within declinations from the North Pole to $-14°$ (Kornilov et al. 1991). In this catalogue, the W–B indices have been reduced to outside the atmosphere by an original method based on the calculation of the extinction coefficients by the numerical convolution of the energy distribution functions, response functions and atmospheric transmission functions at the corresponding air mass (Moshkalev and Khaliullin 1985).

The color indices W–B, B–V and V–R of the Kornilov et al. catalogue are given in the instrumental system with the normalization to zero for the stars of spectral type A0 V. The color transformation of these indices to the *UBVR* system has been investigated by Straižys (1973, 1992) and Meištas et al. (1975) and to the system *UBV* by Kornilov et al. (1991). The transformation of W–B to U–B is strongly non-linear and multivalued. The transformation accuracy of the order of ± 0.03 mag can be achieved only in the case when luminosity classes and color excesses of the stars are known. The transformation of B–V of both the systems is almost linear with some bendings for B- and M-type stars. The transformation of V–R to the Johnson's system is more complicated and requires a parabolic term.

The Kornilov et al. (1991) catalogue is used here for determination of the intrinsic color indices of the *WBVR* system. The obtained results are compared with the intrinsic color indices of the *UBV* system.

2. Selection of normal stars of different spectral types

For the determination of the intrinsic color indices, we have made selection of stars with the normal MK spectral types. The following stars have been excluded from the analysis:

(1) the stars without known MK luminosity classes as well as the stars with intermediate (IV–V or III–IV) luminosity classes, peculiar and binary stars,

(2) the stars with a single observation in the *WBVR* system,

(3) the stars brighter than $V = 3.0$ mag to avoid the large corrections for the non-linearity of the photometer response and other effects; only in the case of supergiants, this limit was lowered to 2.0,

(4) the stars with $E_{B-V} > 0.40$ to avoid possible variations of the interstellar reddening law.

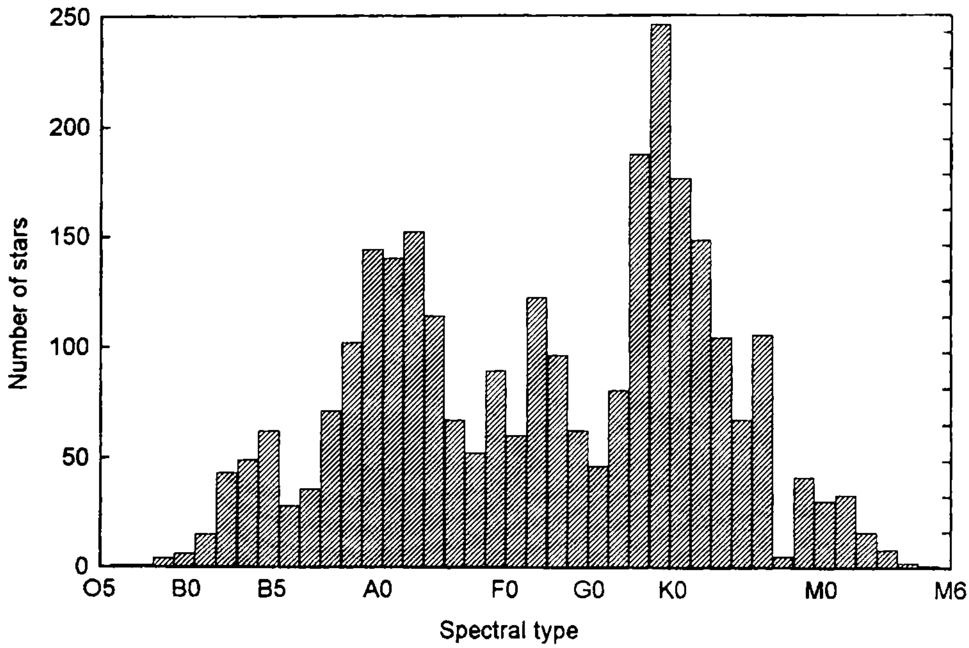

Fig. 1. Distribution of the used stars in spectral types.

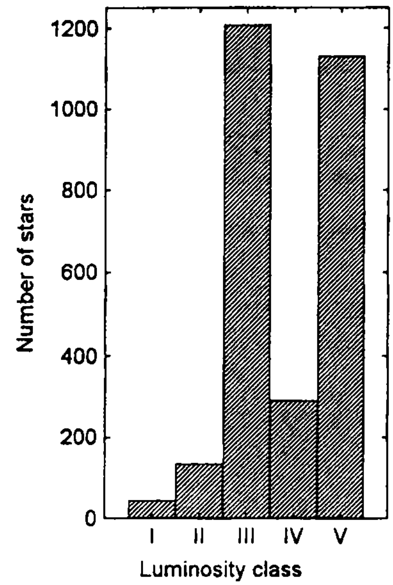

Fig. 2. Distribution of the used stars in luminosity classes.

After the above limitation, we get 2849 stars which have been used in the further dereddening process. Their distribution in spectral and luminosity classes is given in Figs. 1 and 2.

3. Determination of the ratios of color excesses

Color excesses $E_{m_1-m_2}$ were obtained from the synthetic color indices m_1–m_2 in the following way:

$$E_{m_1-m_2} = m_1 - m_2 - (m_1 - m_2)_0$$

and

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

Here $F(\lambda)$ are the energy distribution functions of stars of different MK classes from Sviderskienė (1988), $S_1(\lambda)$ and $S_2(\lambda)$ are the response functions of the passbands from Kornilov et al. (1991), $\tau(\lambda)$ is the standard transmission function of the unit quantity of interstellar dust from Straižys (1992) and x is the number of dust units. For calculation of m_1–m_2 of the reddened stars we took $x = 1.0$ corresponding to $E_{B-V} = 1.0$. For calculation of the intrinsic $(m_1$–$m_2)_0$, the value of $x = 0$ has been taken.

The calculated values of E_{W-B}/E_{B-V} and E_{V-R}/E_{B-V} for the spectral types represented in the Sviderskienė (1988) catalogue are given in Table 1. Together we present the synthetic color indices normalized to zero for a A0 V star.

Table 1. Intrinsic color indices and excess ratios calculated from the energy distribution curves

Sp	$(W-B)_0$	$(B-V)_0$	$(V-R)_0$	$\frac{E_{W-B}}{E_{B-V}}$	$\frac{E_{V-R}}{E_{B-V}}$
O V	-1.404	-0.322	-0.227	0.793	0.862
B0 V	-1.351	-0.280	-0.197	0.793	0.862
B1 V	-1.190	-0.257	-0.178	0.791	0.863
B3 V	-0.911	-0.189	-0.130	0.796	0.867
B5 V	-0.702	-0.133	-0.070	0.789	0.867
B7 V	-0.437	-0.098	-0.064	0.787	0.869
B8 V	-0.319	-0.074	-0.046	0.787	0.869
B9 V	-0.222	-0.035	-0.044	0.791	0.876
A0 V	0.000	0.000	0.000	0.785	0.869
A2 V	0.050	0.051	0.021	0.798	0.877
A3 V	0.062	0.097	0.043	0.804	0.876
A5 V	0.095	0.124	0.086	0.809	0.881
A7 V	0.035	0.200	0.170	0.805	0.874
F0 V	-0.061	0.318	0.264	0.826	0.876
F2 V	-0.081	0.371	0.336	0.834	0.876
F5 V	-0.084	0.416	0.377	0.834	0.872
F6 V	-0.105	0.473	0.410	0.842	0.877
F8 V	-0.071	0.530	0.458	0.854	0.882
G0 V	-0.035	0.587	0.496	0.858	0.880
G2 V	0.019	0.621	0.532	0.868	0.882
G5 V	0.041	0.656	0.553	0.872	0.877
G8 V	0.116	0.753	0.599	0.892	0.881
K0 V	0.270	0.838	0.664	0.902	0.880
K2 V	0.445	0.907	0.742	0.924	0.879
K3 V	0.645	0.990	0.831	0.933	0.874
K4 V	0.759	1.093	0.942	0.943	0.865
K5 V	0.962	1.207	1.030	0.941	0.853
K7 V	1.078	1.387	1.176	0.957	0.861
M0 V	1.040	1.460	1.261	0.954	0.868
M2 V	1.098	1.539	1.468	0.960	0.895
M3 V	1.065	1.553	1.589	0.937	0.907
M4 V	1.053	1.570	1.702	0.926	0.928
M5 V	1.076	1.762	1.839	0.986	0.965
M5.5 V	1.255	1.823	1.952	0.992	0.969
M7 V	1.282	1.848	2.165	0.999	1.013

Table 1 (continued)

Sp	$(W\text{-}B)_0$	$(B\text{-}V)_0$	$(V\text{-}R)_0$	$\frac{E_{W-B}}{E_{B-V}}$	$\frac{E_{V-R}}{E_{B-V}}$
A4 IV	0.094	0.102	0.081	0.807	0.880
F0 IV	-0.002	0.303	0.276	0.826	0.878
F2 IV	-0.046	0.352	0.320	0.826	0.873
F5 IV	-0.065	0.447	0.378	0.842	0.873
F8 IV	-0.073	0.551	0.428	0.857	0.884
G0 IV	-0.006	0.611	0.478	0.871	0.887
G2 IV	0.051	0.657	0.513	0.882	0.890
G5 IV	0.152	0.734	0.578	0.890	0.883
G8 IV	0.280	0.848	0.670	0.900	0.878
K0 IV	0.488	0.948	0.729	0.917	0.883
K1 IV	0.696	1.035	0.786	0.931	0.883
K3 IV	1.035	1.210	0.880	0.953	0.890
B9 III	-0.132	-0.057	-0.041	0.776	0.867
A3 III	0.144	0.117	0.068	0.791	0.870
A5 III	0.100	0.162	0.124	0.802	0.872
A7 III	0.140	0.199	0.160	0.809	0.879
F0 III	0.096	0.271	0.229	0.822	0.882
F2 III	0.010	0.374	0.320	0.821	0.873
F5 III	0.097	0.492	0.386	0.835	0.871
G0 III	0.090	0.678	0.547	0.861	0.873
G5 III	0.309	0.891	0.668	0.907	0.888
G8 III	0.489	0.954	0.706	0.923	0.890
K0 III	0.662	1.037	0.744	0.936	0.894
K1 III	0.795	1.107	0.803	0.949	0.897
K2 III	1.027	1.194	0.846	0.964	0.899
K3 III	1.320	1.343	0.918	0.981	0.896
K4 III	1.434	1.439	1.019	0.990	0.895
K5 III	1.628	1.553	1.162	1.001	0.900
M0 III	1.790	1.595	1.230	1.010	0.918
M1 III	1.803	1.654	1.294	1.004	0.918
M2 III	1.867	1.663	1.356	1.006	0.931
M3 III	1.764	1.689	1.532	0.982	0.943
M4 III	1.719	1.623	1.745	0.960	0.973
M5 III	1.590	1.662	2.055	0.896	0.986
M6 III	1.384	1.651	2.417	0.819	0.966
M7 III	1.121	1.654	2.974	0.683	0.916

Table 1 (continued)

Sp	$(W-B)_0$	$(B-V)_0$	$(V-R)_0$	$\frac{E_{W-B}}{E_{B-V}}$	$\frac{E_{V-R}}{E_{B-V}}$
B2 II	-1.181	-0.187	-0.130	0.800	0.860
B5 II	-0.851	-0.129	-0.089	0.792	0.860
F0 II	0.388	0.159	0.161	0.759	0.871
B2 II	-1.181	-0.187	-0.130	0.800	0.860
B5 II	-0.851	-0.129	-0.089	0.792	0.860
F0 II	0.388	0.159	0.161	0.759	0.871
F2 II	0.182	0.331	0.270	0.801	0.871
G5 II	0.404	0.906	0.633	0.911	0.887
K1 II	0.998	1.258	0.781	0.974	0.897
K2 II	1.272	1.347	0.887	0.988	0.909
K3 II	1.561	1.527	1.015	1.015	0.915
M3 II	1.914	1.755	1.565	0.978	0.963
M4 II	1.733	1.727	1.852	0.933	0.987
O I	-1.451	-0.386	-0.256	0.790	0.862
B0 Ia	-1.338	-0.211	-0.142	0.800	0.860
B1 Ib	-1.256	-0.176	-0.108	0.800	0.862
B3 Iab	-1.057	-0.110	-0.076	0.797	0.859
B5 Iab	-0.936	-0.059	0.006	0.793	0.862
B8 Ia	-0.833	-0.019	0.028	0.792	0.863
A0 Ib	-0.246	0.009	0.069	0.763	0.861
A2 Ia	-0.270	0.092	0.093	0.766	0.864
F0 Ib	0.388	0.209	0.203	0.756	0.874
F5 Ib	0.320	0.410	0.305	0.816	0.881
F8 Iab	0.440	0.587	0.394	0.843	0.883
G0 Ib	0.365	0.779	0.527	0.885	0.885
G2 Ib	0.481	0.909	0.585	0.916	0.890
G5 Ib	0.669	1.055	0.666	0.928	0.886
G8 Iab	1.136	1.269	0.822	0.962	0.896
K2 Ib	1.490	1.563	0.987	1.012	0.903
K3 Ib	1.686	1.620	1.096	1.012	0.896
K4 Ib	1.731	1.702	1.207	0.999	0.905
M2 Iab	1.857	1.949	1.596	1.016	0.959

4. Dereddening and intrinsic indices

The observed color indices of the selected stars have been dereddened by subtracting their color excess

$$E_{B-V} = (B-V)_{\text{obs}} - (B-V)_0,$$

where $(B-V)_0$ were taken from Straižys (1992) monograph for the corresponding spectral and luminosity classes. The excesses E_{W-B} and E_{V-R} were determined using the ratios of color excesses given in Table 1 (interpolation in some cases was necessary). Color excesses E_{B-V} have been considered to coincide in both the systems.

Only the stars with $E_{B-V} > 0.02$ have been dereddened. The stars, for which $(B-V)-(B-V)_0$ was ≤ 0.02 (including the negative values), were considered as being unreddened.

Color indices of both unreddened and dereddened stars have been plotted against spectral types for different luminosity classes (Figs. 3–17). All stars of luminosity classes Ia and Iab were considered together. The majority of B and A supergiants are of luminosity Iab, while the G and K supergiants are mostly of luminosity Ib.

The average lines have been drawn in Figs. 3–17, using the cubic splines. The scatter of dereddened points around the average lines is characterized by the r.m.s. scattering given in Table 2.

Table 2. The r.m.s. scattering of the intrinsic color indices

Luminosity	$(W-B)_0$	$(B-V)_0$	$(V-R)_0$
V	0.08	0.02	0.02
IV	0.09	0.02	0.02
III	0.10	0.03	0.04
II	0.11	0.03	0.03
I	0.10	0.03	0.04

The intrinsic color indices counted from the average lines are listed in Tables 3–5.

In Fig. 6 the intrinsic line of $(W-V)_0$ for B6–A5 luminosity II stars is drawn a little higher than the circles of the three individual stars indicate. These stars lie even lower than the mean line of luminosity Ib stars. This contradicts the general dependence of $(W-V)_0$ on the luminosity. Therefore, we decided to take the luminosity Ib line to represent the luminosity II intrinsic colors in this spectral range.

In Figs. 18 and 19 the intrinsic sequences of V, III, and I luminosity classes are plotted in the diagrams $W-B$, $B-V$ and $V-R$, $B-V$. One can see the luminosity effects which are the strongest among A

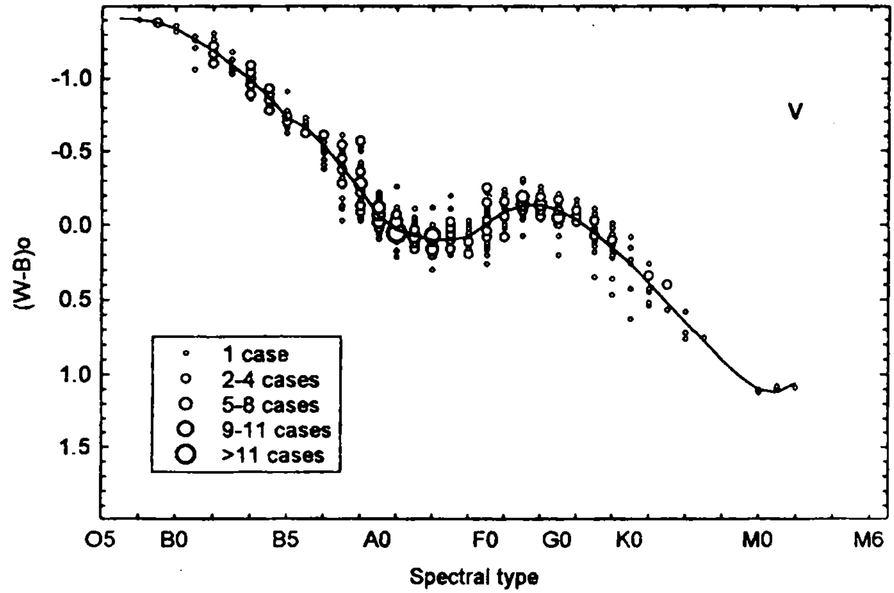

Fig. 3. Intrinsic color indices $(W\text{–}B)_0$ for luminosity V stars.

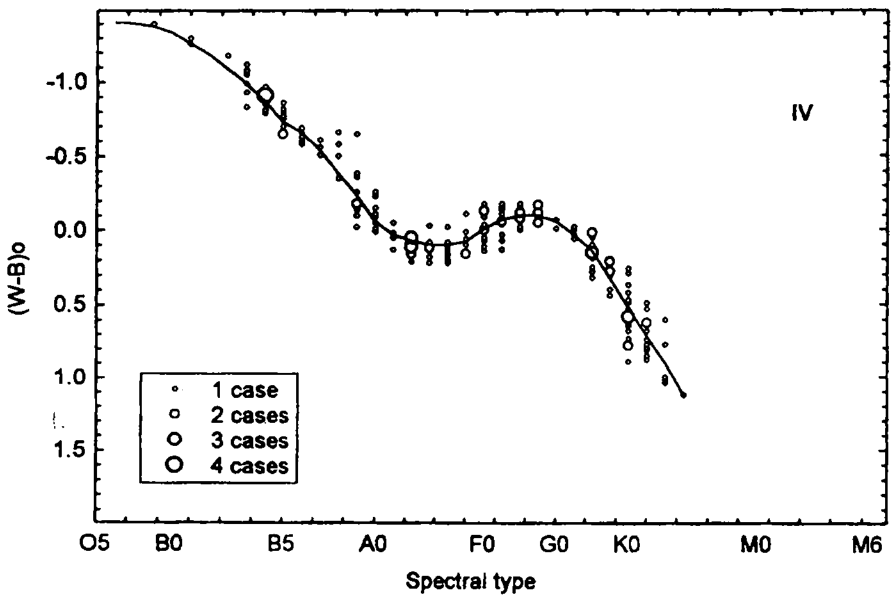

Fig. 4. Intrinsic color indices $(W\text{–}B)_0$ for luminosity IV stars.

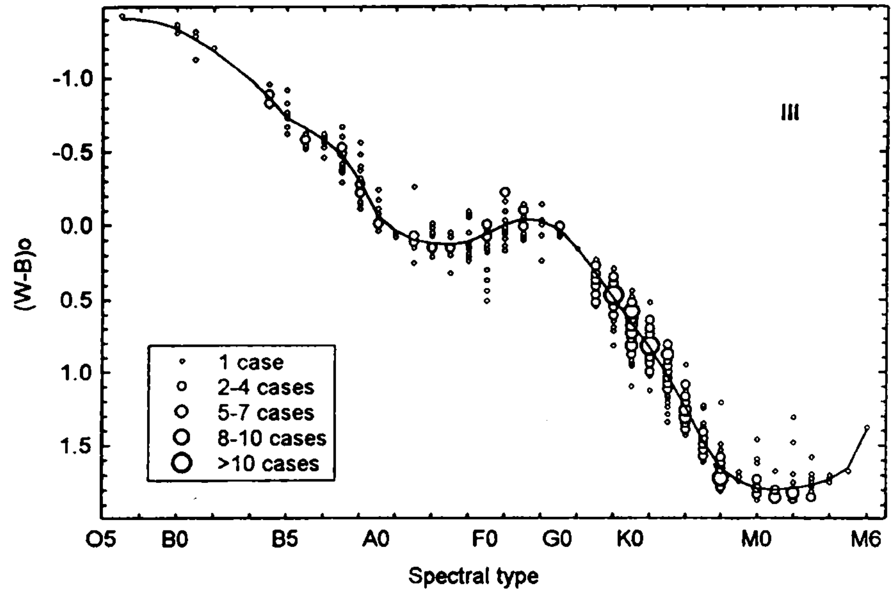

Fig. 5. Intrinsic color indices $(W\text{–}B)_0$ for luminosity III stars.

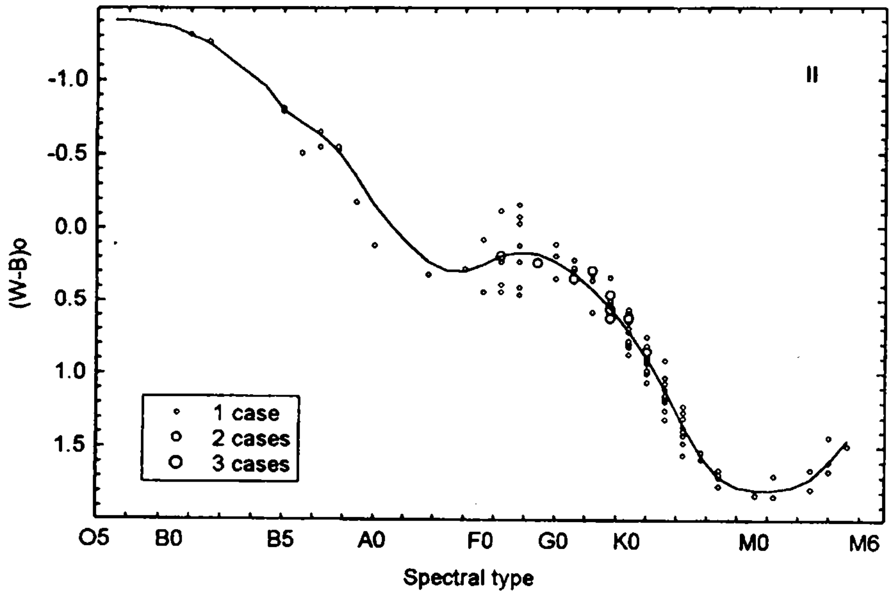

Fig. 6. Intrinsic color indices $(W\text{–}B)_0$ for luminosity II stars.

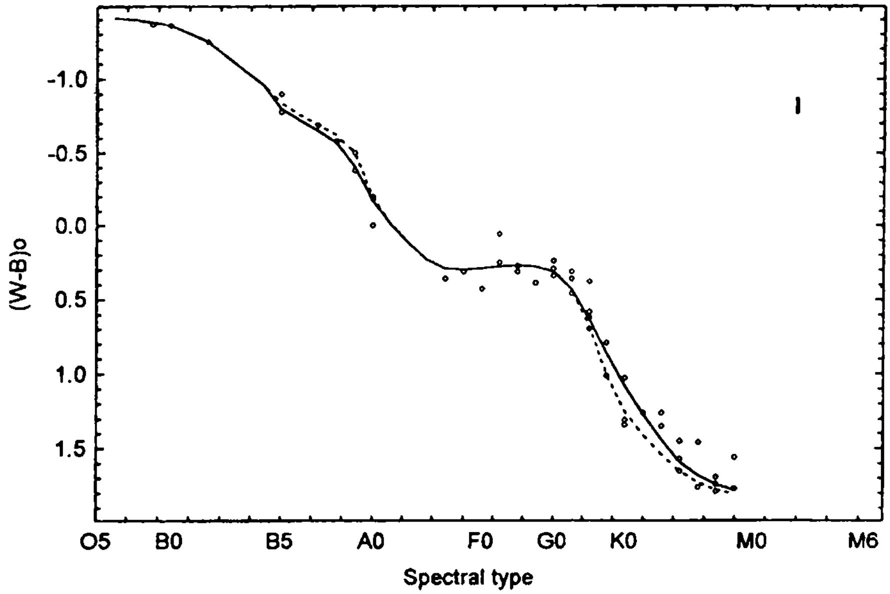

Fig. 7. Intrinsic color indices $(W\text{–}B)_0$ for luminosity I stars: the solid line is for Ib and the broken line is for Ia+Iab luminosity classes.

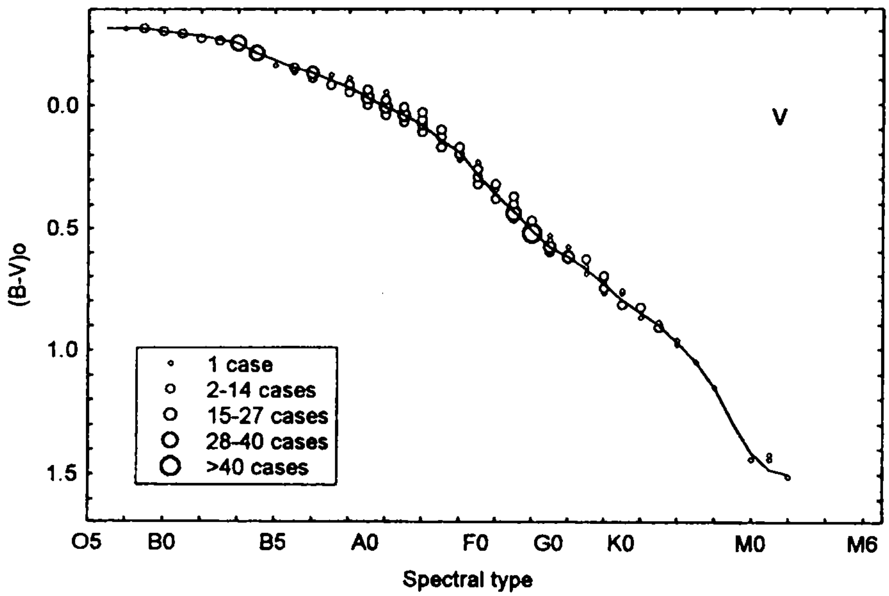

Fig. 8. Intrinsic color indices $(B\text{–}V)_0$ for luminosity V stars.

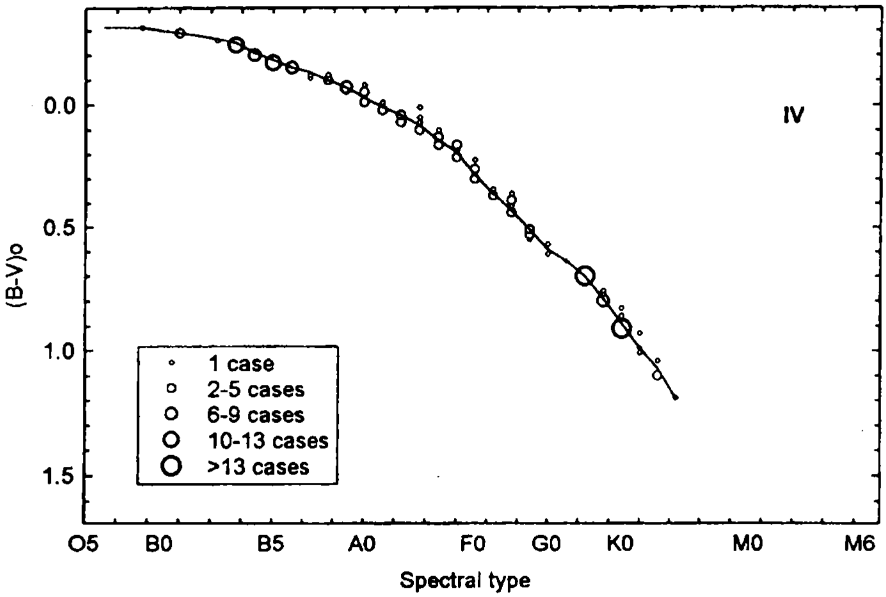

Fig. 9. Intrinsic color indices $(B-V)_0$ for luminosity IV stars.

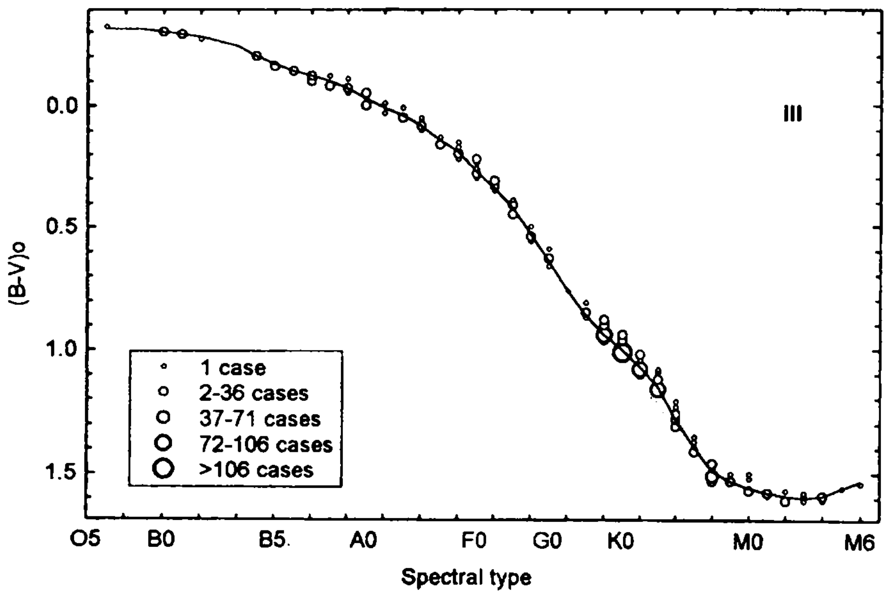

Fig. 10. Intrinsic color indices $(B-V)_0$ for luminosity III stars.

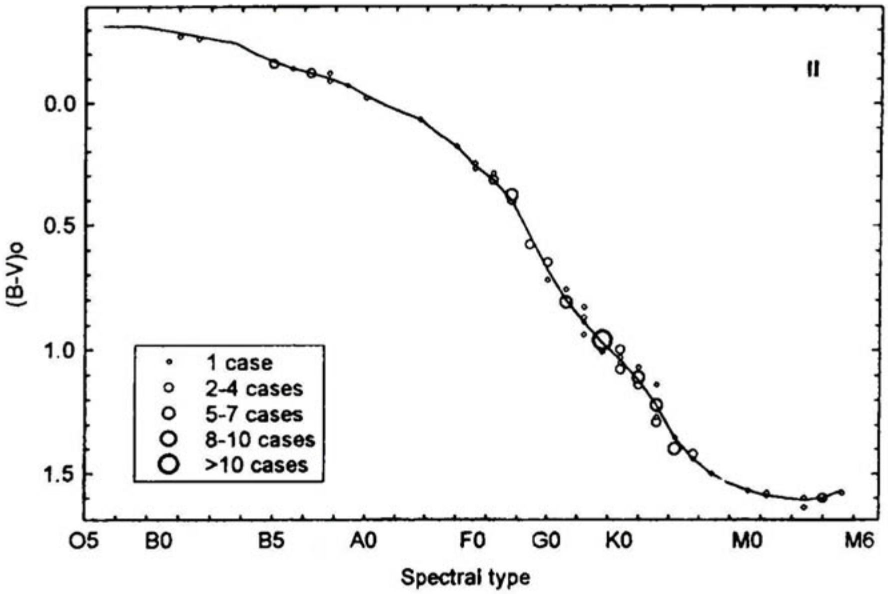

Fig. 11. Intrinsic color indices $(B-V)_0$ for luminosity II stars.

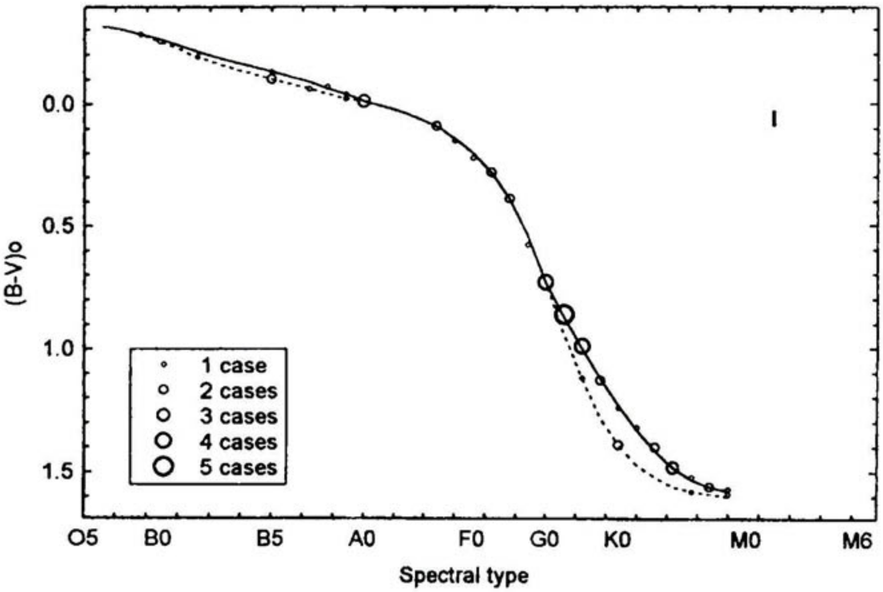

Fig. 12. Intrinsic color indices $(B-V)_0$ for luminosity I stars: the solid line is for Ib and the broken line is for Ia+Iab luminosity classes.

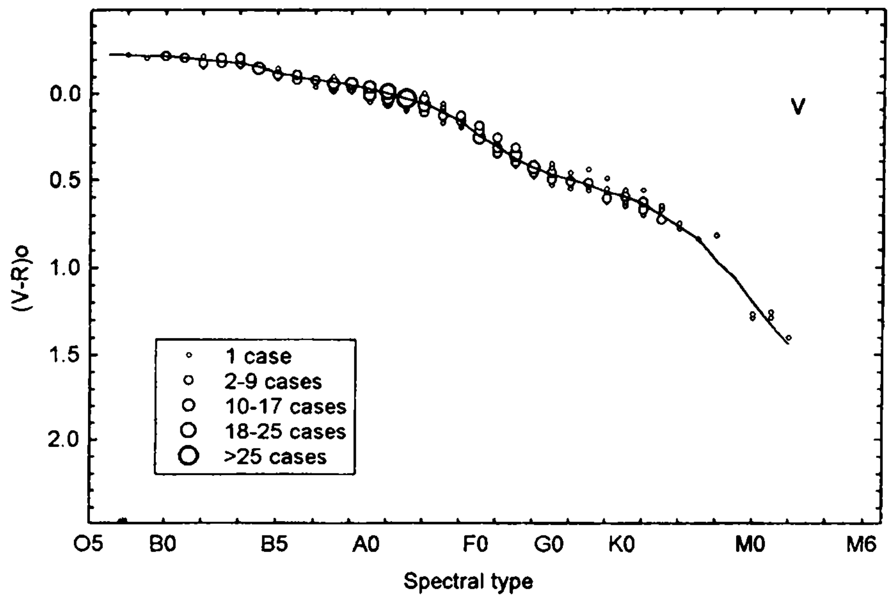

Fig. 13. Intrinsic color indices $(V\text{–}R)_0$ for luminosity V stars.

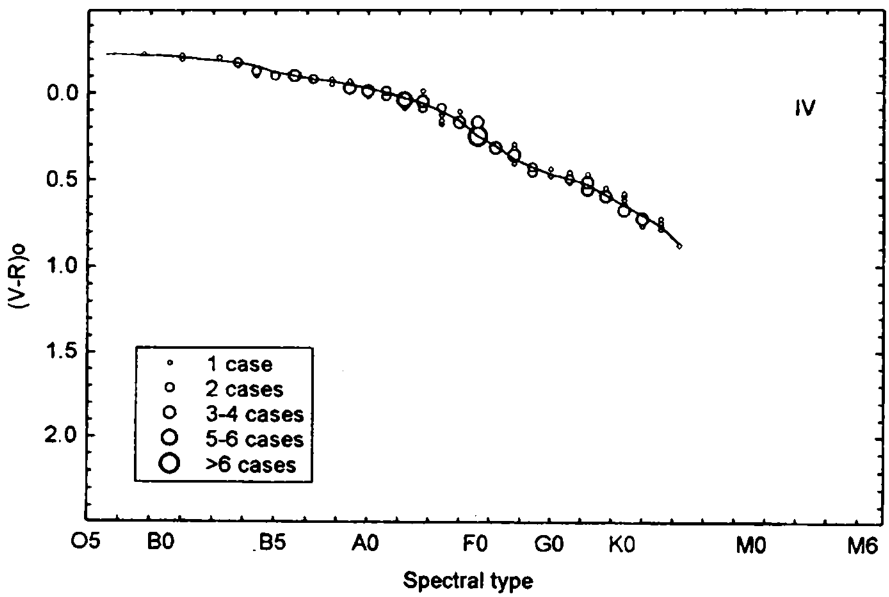

Fig. 14. Intrinsic color indices $(V\text{–}R)_0$ for luminosity IV stars.

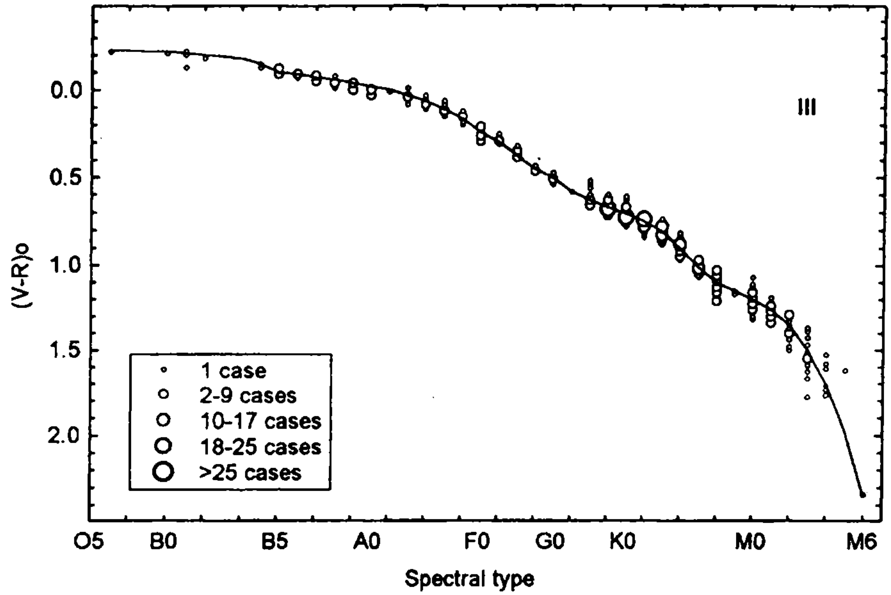

Fig. 15. Intrinsic color indices $(V–R)_0$ for luminosity III stars.

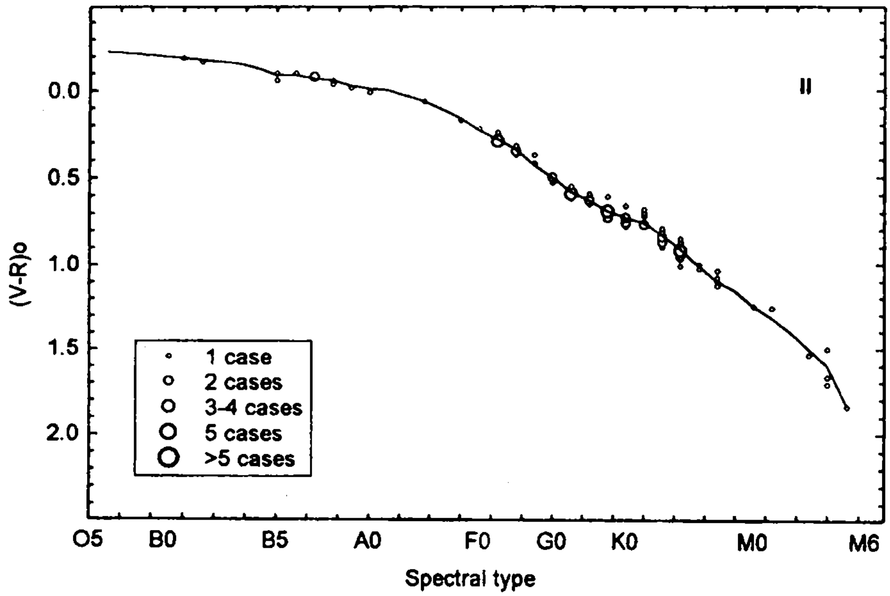

Fig. 16. Intrinsic color indices $(V–R)_0$ for luminosity II stars.

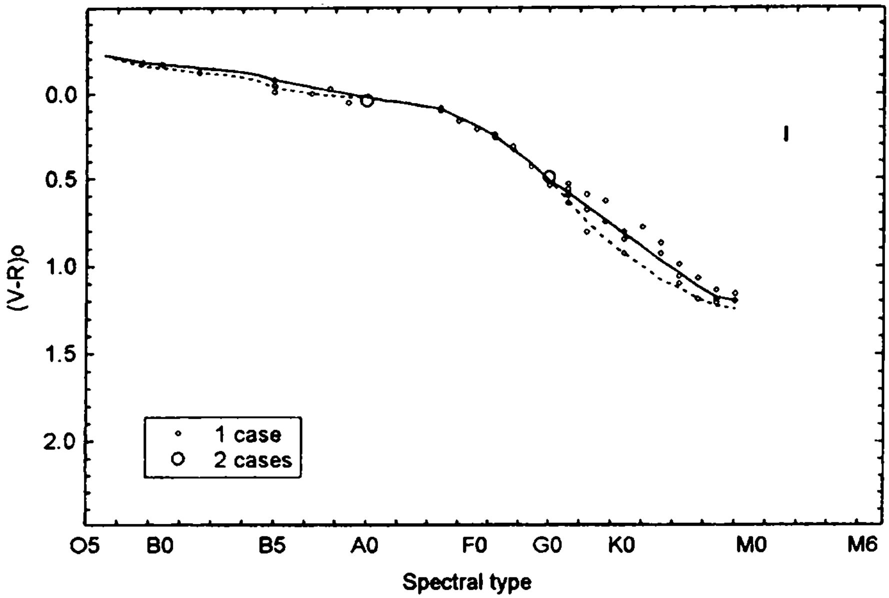

Fig. 17. Intrinsic color indices $(V\text{-}R)_0$ for luminosity I stars: the solid line is for Ib and the broken line is for Ia+Iab luminosity classes.

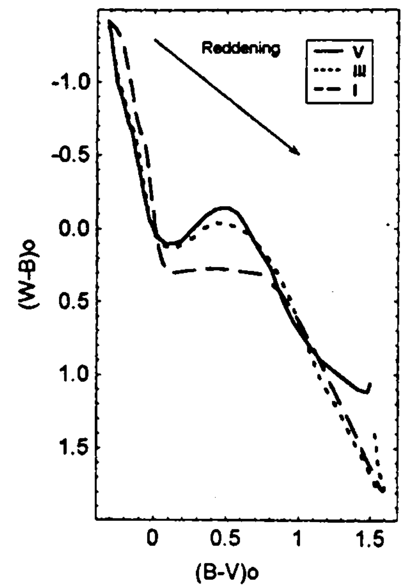

Fig. 18. Intrinsic sequences of luminosity V, III and I stars in the $W\text{-}B$, $B\text{-}V$ diagram.

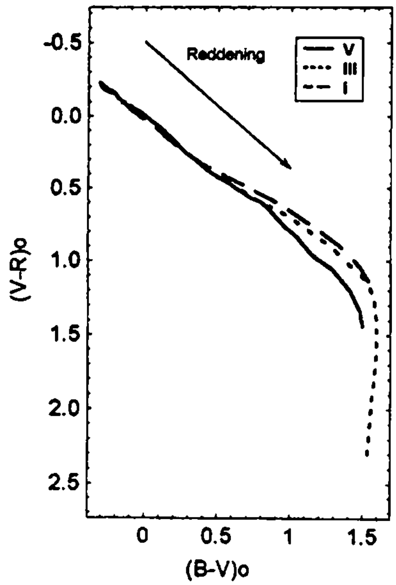

Fig. 19. Intrinsic sequences of luminosity V, III and I stars in the $V\text{-}R$, $B\text{-}V$ diagram.

Table 3. Intrinsic color indices $(W-B)_0$

Sp	V	IV	III	II	Ib	Iab
O7	-1.41	-1.41	-1.41	-1.41	-1.41	-1.41
O8	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40
O9	-1.38	-1.38	-1.38	-1.38	-1.38	-1.38
B0	-1.34	-1.34	-1.34	-1.36	-1.36	-1.36
B1	-1.19	-1.19	-1.19	-1.25	-1.25	-1.25
B2	-0.99	-0.99	-0.99	-1.05	-1.05	-1.05
B3	-0.87	-0.87	-0.87	-0.96	-0.96	-0.96
B5	-0.73	-0.73	-0.73	-0.80	-0.80	-0.84
B6	-0.66	-0.66	-0.66	-0.71	-0.72	-0.76
B7	-0.54	-0.54	-0.58	-0.63	-0.65	-0.69
B8	-0.39	-0.39	-0.48	-0.52	-0.57	-0.62
B9	-0.24	-0.24	-0.30	-0.35	-0.41	-0.50
A0	-0.06	-0.06	-0.06	-0.16	-0.17	-0.20
A1	0.03	0.03	0.04	-0.01	-0.01	-0.01
A2	0.07	0.07	0.10	0.12	0.12	0.12
A3	0.10	0.10	0.12	0.23	0.23	0.23
A5	0.10	0.10	0.13	0.29	0.29	0.29
A7	0.08	0.08	0.11	0.30	0.30	0.30
F0	-0.01	-0.01	0.06	0.25	0.29	0.29
F2	-0.09	-0.07	0.00	0.19	0.28	0.28
F5	-0.13	-0.10	-0.04	0.17	0.27	0.27
F8	-0.14	-0.10	-0.02	0.18	0.28	0.28
G0	-0.10	-0.06	0.03	0.23	0.31	0.31
G2	-0.04	0.03	0.16	0.31	0.43	0.43
G5	0.05	0.14	0.32	0.42	0.63	0.68
G8	0.15	0.32	0.49	0.55	0.86	1.00
K0	0.26	0.52	0.66	0.71	1.08	1.25
K1	0.39	0.71	0.83	0.89	1.27	1.41
K2	0.52	0.90	1.03	1.11	1.44	1.54
K3	0.65	1.12	1.24	1.35	1.59	1.65
K4	0.77		1.47	1.56	1.68	1.73
K5	0.90		1.65	1.70	1.74	1.78
K7	1.01		1.74	1.77	1.78	1.80
M0	1.10		1.79	1.79		
M1	1.12		1.80	1.79		
M2	1.06		1.79	1.77		
M3			1.77	1.71		
M4			1.73	1.60		
M5			1.65	1.45		
M6			1.39			

Table 4. Intrinsic color indices $(B-V)_0$

Sp	V	IV	III	II	Ib	Iab
O7	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31
O8	-0.31	-0.31	-0.31	-0.31	-0.30	-0.30
O9	-0.31	-0.31	-0.31	-0.31	-0.28	-0.28
B0	-0.30	-0.30	-0.30	-0.30	-0.26	-0.25
B1	-0.28	-0.28	-0.28	-0.27	-0.21	-0.19
B2	-0.25	-0.25	-0.24	-0.24	-0.17	-0.14
B3	-0.21	-0.21	-0.20	-0.20	-0.15	-0.12
B5	-0.18	-0.18	-0.17	-0.17	-0.13	-0.10
B6	-0.15	-0.15	-0.14	-0.14	-0.11	-0.08
B7	-0.13	-0.13	-0.12	-0.12	-0.09	-0.06
B8	-0.10	-0.10	-0.10	-0.10	-0.06	-0.04
B9	-0.07	-0.07	-0.07	-0.07	-0.04	-0.02
A0	-0.03	-0.03	-0.03	-0.03	-0.01	-0.01
A1	0.01	0.01	0.01	0.01	0.01	0.01
A2	0.04	0.04	0.04	0.04	0.03	0.03
A3	0.08	0.08	0.08	0.07	0.06	0.06
A5	0.14	0.14	0.14	0.13	0.09	0.09
A7	0.19	0.19	0.19	0.18	0.14	0.14
F0	0.28	0.28	0.27	0.26	0.20	0.20
F2	0.36	0.36	0.34	0.32	0.28	0.28
F5	0.43	0.43	0.42	0.40	0.39	0.39
F8	0.51	0.51	0.53	0.54	0.54	0.54
G0	0.58	0.59	0.64	0.68	0.73	0.73
G2	0.62	0.64	0.76	0.80	0.87	0.94
G5	0.67	0.70	0.86	0.89	1.00	1.12
G8	0.73	0.79	0.94	0.97	1.12	1.28
K0	0.80	0.89	1.00	1.04	1.23	1.39
K1	0.85	0.99	1.07	1.12	1.33	1.47
K2	0.90	1.07	1.15	1.22	1.41	1.52
K3	0.97	1.19	1.28	1.35	1.48	1.56
K4	1.05		1.39	1.44	1.53	1.58
K5	1.15		1.49	1.50	1.56	1.59
K7	1.29		1.53	1.54	1.58	1.60
M0	1.41		1.56	1.57		
M1	1.48		1.58	1.59		
M2	1.50		1.59	1.60		
M3			1.60	1.61		
M4			1.59	1.60		
M5			1.56	1.57		
M6			1.53			

Table 5. Intrinsic color indices $(V\text{–}R)_0$

Sp	V	IV	III	II	Ib	Iab
O7	–0.23	–0.23	–0.23	–0.23	–0.22	–0.22
O8	–0.23	–0.23	–0.23	–0.22	–0.20	–0.19
O9	–0.22	–0.22	–0.22	–0.21	–0.18	–0.16
B0	–0.22	–0.22	–0.22	–0.20	–0.17	–0.15
B1	–0.20	–0.20	–0.20	–0.18	–0.15	–0.12
B2	–0.18	–0.18	–0.18	–0.16	–0.13	–0.10
B3	–0.16	–0.16	–0.15	–0.13	–0.11	–0.08
B5	–0.12	–0.12	–0.10	–0.09	–0.08	–0.04
B6	–0.10	–0.10	–0.09	–0.09	–0.06	–0.02
B7	–0.08	–0.08	–0.07	–0.07	–0.04	0.00
B8	–0.07	–0.07	–0.06	–0.06	–0.02	0.01
B9	–0.05	–0.05	–0.04	–0.03	0.00	0.02
A0	–0.03	–0.03	–0.02	–0.01	0.02	0.02
A1	0.00	0.00	0.00	0.00	0.04	0.04
A2	0.03	0.03	0.03	0.03	0.05	0.05
A3	0.06	0.06	0.06	0.06	0.07	0.07
A5	0.11	0.11	0.11	0.11	0.09	0.09
A7	0.16	0.16	0.16	0.16	0.14	0.14
F0	0.25	0.25	0.24	0.23	0.19	0.19
F2	0.31	0.31	0.30	0.28	0.25	0.25
F5	0.38	0.38	0.37	0.34	0.33	0.33
F8	0.43	0.43	0.45	0.43	0.41	0.41
G0	0.47	0.47	0.50	0.50	0.51	0.51
G2	0.50	0.50	0.58	0.58	0.58	0.63
G5	0.53	0.53	0.63	0.63	0.66	0.75
G8	0.57	0.59	0.67	0.69	0.74	0.85
K0	0.60	0.65	0.71	0.73	0.82	0.93
K1	0.64	0.71	0.75	0.76	0.89	1.00
K2	0.70	0.77	0.81	0.83	0.97	1.08
K3	0.77	0.87	0.90	0.91	1.04	1.13
K4	0.84		1.01	1.01	1.12	1.19
K5	0.96		1.10	1.10	1.18	1.23
K7	1.06		1.15	1.16	1.20	1.25
M0	1.20		1.20	1.25		
M1	1.33		1.26	1.32		
M2	1.44		1.35	1.40		
M3			1.50	1.50		
M4			1.70	1.60		
M5			1.98	1.83		
M6			2.35			

and F stars in the case of W–B, B–V diagram and among G and K stars in the case of V–R, B–V diagram.

5. Comparison of intrinsic indices of the *WBVR* and *UBVR* systems

Figs. 20–22 exhibit differences between the corresponding intrinsic color indices of the *WBVR* and *UBVR* systems as a function of $(B-V)_0$. The difference $(W-B)_0$ – $(U-B)_0$ shows the same features of the sequences as it was obtained earlier by Straižys (1973) and Meištas et al. (1975). The W–B index has much larger range of variation for B-type stars and especially for A and F supergiants. In the case of B–V, the differences > 0.05 mag are observable only for K-type supergiants. Color indices V–R of both systems are also very close.

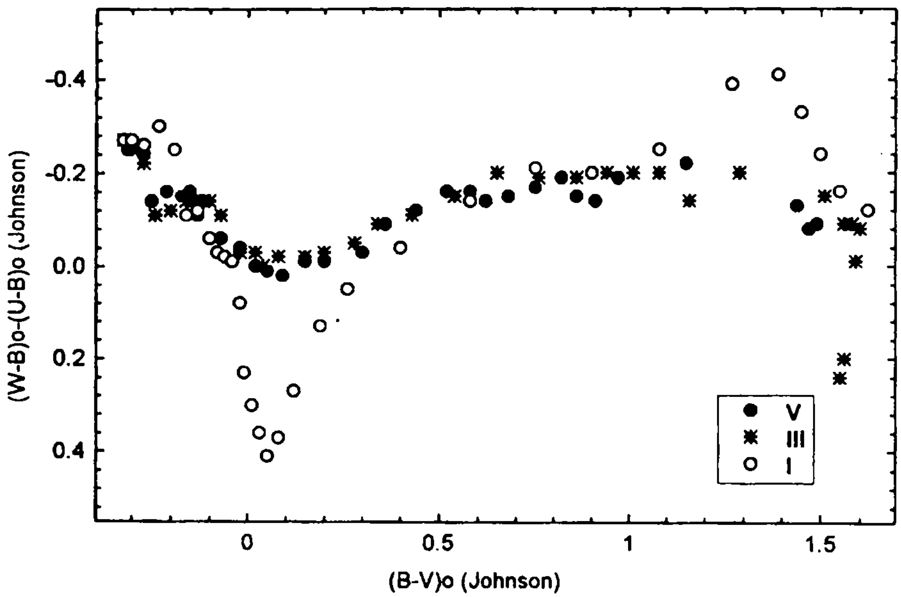

Fig. 20. The difference of the intrinsic color indices $(W-B)_0$ and $(U-B)_0$ of the *WBVR* and the *UBVR* systems, as a function of $(B-V)_0$.

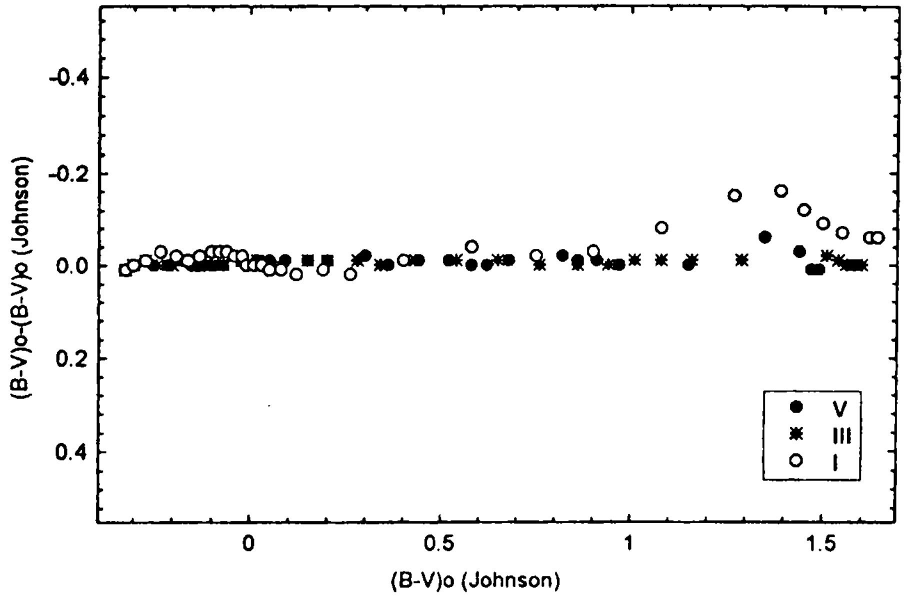

Fig. 21. The difference of the intrinsic color indices $(B-V)_0$ of the *WBVR* and the *UBVR* systems, as a function of $(B-V)_0$.

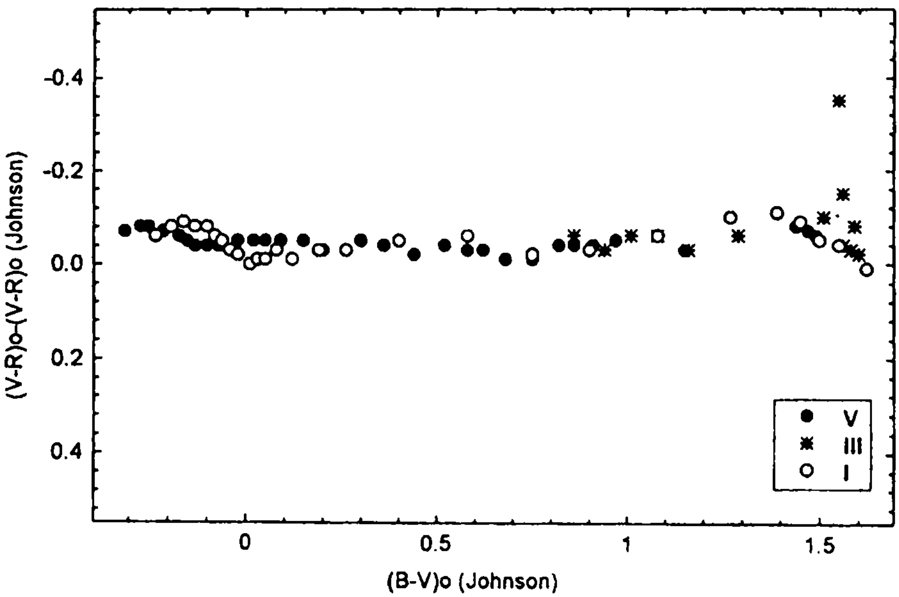

Fig. 22. The difference of the intrinsic color indices $(V-R)_0$ of the *WBVR* and the *UBVR* systems, as a function of $(B-V)_0$.

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