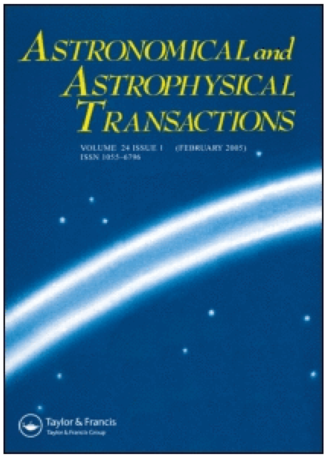

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Spectrophotometric standards of 7^m-8^m: Supplement 1

G. V. Borisov [a]; I. N. Glushneva [a]; V. I. Shenavrin [a]
[a] Sternberg State Astronomical Institute, University of Moscow, Moscow, Russia

Online Publication Date: 01 April 1998
To cite this Article: Borisov, G. V., Glushneva, I. N. and Shenavrin, V. I. (1998) 'Spectrophotometric standards of 7^m-8^m: Supplement 1', Astronomical & Astrophysical Transactions, 17:4, 309 - 320
To link to this article: DOI: 10.1080/10556799808232097
URL: http://dx.doi.org/10.1080/10556799808232097

Astronomical and Astrophysical Transactions, 1998, Vol. 17, pp. 309–320
Reprints available directly from the publisher
Photocopying permitted by license only

SPECTROPHOTOMETRIC STANDARDS OF 7^m–8^m: SUPPLEMENT 1

G. V. BORISOV, I. N. GLUSHNEVA, and V. I. SHENAVRIN

Sternberg State Astronomical Institute, University of Moscow, 13 Universitetskij Prospect, 119899, Moscow, Russia.

(Received November 28, 1997)

This paper is the continuation of our previous work including energy distribution data for 60 stars of spectral type A0–G2 in the range 3425–7525Å. The energy distribution for 22 stars of spectral type A0–G0 in the same spectral range is presented in Supplement 1. The mean accuracy of the energy distribution data obtained is about 2% in the ultraviolet, 1% in the visual range and 1.5–2% for $\lambda > 7000$Å. For five stars common with the *WBVR* photometric catalogue synthetic $B - V$ indices are calculated. The comparison of the synthetic and observed $B - V$ indices demonstrates good agreement between spectrophotometry and *WBVR* photometry. These stars may be used as spectrophotometric standards.

KEY WORDS **Photometry, spectrophotometry, stars**

1 INTRODUCTION

A set of 60 spectrophotometric standards of 7–8 mag was presented in the paper by Biryukov *et al.* (1998) – hereafter referred to as Paper 1.

These 60 stars belonging to the A0–G2 spectral type are not members of the General Catalogue of Variable Stars (fourth edition) or the New Catalogue of Suspected Variable Stars.

Energy distribution data in the range 3425–7525Å are presented with 50Å steps. The reliability of the spectral energy distribution was confirmed by means of the comparison of the synthetic $B - V$ colour indices calculated on the basis of energy distribution data and observed colour indices. This comparison demonstrates good agreement between spectrophotometry and *WBVR* photometry.

2 OBSERVATIONAL PROGRAM

Observations were made at the Sternberg Institute Crimean Station in the framework of investigations connected with the preparation of the space project Lomono-

Table 1. List of programme stars proposed as secondary spectrophotometric standards

HD	*Sp*	*V*	$B - V$	*Reference*
896	F0 V	8.0	0.4	Sky Cat. 2000.0
1094	F5	7.334	0.433	Metlov
18031	F2 V	7.216	0.380	Kornilov *et al.*
26141	A0 V	7.6	0.1	Sky Cat. 2000.0
27887	F5 V	7.84	0.44	Sky Cat. 2000.0
68933	F5 V	7.5	0.5	Sky Cat. 2000.0
83616	G0	7.875	0.580	Metlov
94118	A3 V	7.472	0.080	Kornilov *et al.*
99233	F8	7.892	0.551	Metlov
124986	F8 V	7.7	0.5	Sky Cat. 2000.0
140320	F5 V	7.9	0.5	Sky Cat. 2000.0
147062	G0 V	7.7	0.6	Sky Cat. 2000.0
153015	A5 V	7.237	0.016	Kornilov *et al.*
160488	F5 V	7.6	0.5	Sky Cat. 2000.0
196218	F8 V	8.0	0.5	Sky Cat. 2000.0
197573	A2 V	7.173	0.129	Kornilov *et al.*
198334	F8 V	7.9	0.5	Sky Cat. 2000.0
198920	F2 V	7.6	0.4	Sky Cat. 2000.0
209665	A0 V	7.221	0.056	Kornilov *et al.*
211784	A3	7.485	0.241	Metlov
213234	A3 V	8.00	0.1	Sky Cat. 2000.0
225054	F8	7.89	0.50	Metlov

sov (Nesterov *et al.*, 1990). The programme stars are located in the zone $\pm 40°$ relatively to the ecliptic.

The criteria and method of choice of 7–8 mag stars of A0–G2 spectral type are presented in the paper by Voroshilov *et al.* (1992). These criteria and methods were used also in Paper 1. As in the previous publication these stars are not members of the *General Catalogue of Variable Stars* (fourth edition) or the *New Catalogue of Suspected Variable Stars.*

The list of programme stars is presented in Table 1.

The V magnitude, spectral type and $B - V$ colour indices are taken from the Sky Catalogue 2000.0 (Hirshfeld and Sinnott, 1982) and the *WBVR* catalogue (Kornilov *et al.*, 1991). For five stars which are absent from these two catalogues the observations of V. G. Metlov at the Crimean Station of the Sternberg Institute are presented.

3 EQUIPMENT AND METHOD OF CORRECTIONS

The registration of stellar spectra was done by means of the photoelectric spectrophotometer installed at the 60-cm Zeiss-600 reflector of the Sternberg Institute Crimean Station. A grating with discrete scanning and a photomultiplier working in the regime of photon counting were used.

A detailed description of the equipment and the method of corrections is presented in Paper 1.

Here we give very brief description of the process of observations and a comparison with standard stars.

The spectral width of the entrance slit was 50Å and an inlet diaphragm of 27.5″ was used. The counting time was 1 s for standard stars and 10 s for programme stars at each spectral interval. Registration of spectra was done according to the scheme: standard star, programme star, background, program star again and standard star again.

The method of equal altitudes was used for the comparison of programme and standard stars. Differential extinction was taken into account with the spectral extinction coefficient obtained on each observational night. The spectra of two standard stars with differences in air mass not less than 0.5 were registered several times during the night.

Observational data were put into computer memory and, using a graphics regime, a continuum was obtained in the region of the Balmer lines of standard star spectra.

The spectral energy distribution of the programme star was calculated using the standard star continuum and the spectral extinction coefficient of the night of observations. The spectrum of the background obtained with the counting time 10 s was subtracted from the spectrum of the programme star preliminary.

Mean energy distribution data were obtained for each programme star on the basis of measurements on 2–5 nights, i.e. 4–10 individual scans were used because on each night the spectrum of the programme star was scanned twice.

4 STANDARD STARS

Eight bright stars spread across the sky were used as standards: β Ari, γ Ori, β Tau, α Leo, η UMa, α Lyr, α Aql, α Peg. These stars served as standards for the spectrophotometric catalogue of the Sternberg Astronomical Institute, including about 1000 stars of different spectral types and luminosities. The main part of this catalogue (735 stars) is published in *Spectrophotometry of Bright Stars* (Voloshina *et al.*, 1982).

The energy distribution in the spectra of standard stars with 100Å steps are presented in Glushneva *et al.* (1992). For convenience we present here monochromatic fluxes of standard stars with the same step (50Å) and at the same wavelengths as for program stars from 3425Å (Table 2).

Numbers in the table like 241–4 mean 241×10^{-4}. The energy distribution data in the spectra of seven standard stars were obtained by means of comparisons with Vega which were done independently at the Fessenkov Astronomical Institute, Alma-Ata, and at the Sternberg Institute Crimean Station. The energy distribution in the spectrum of Vega, the main spectrophotometric standard, was taken on the basis of the data published by Hayes (1985).

Table 2. The energy distribution of standard stars (erg cm^{-2} s^{-1} cm^{-1}). Numbers in the table like 241–4 mean 241×10^{-4}

	BS553	*BS1790*	*BS1791*	*BS3982*	*BS5191*	*BS7001*	*BS7557*	*BS8781*
3425	241–4	285–3	154–3	163–3	171–3	320–3	130–3	347–4
3475	239	272	149	157	163	313	129	341
3525	239	261	145	153	157	309	128	338
3575	239	249	142	149	152	306	129	334
3625	240	237	139	146	146	304	130	331
3675	247	229	139	147	141	306	134	336
3725	251	206	137	148	130	318	136	355
3775	320	225	168	190	146	422	171	479
3825	402	243	197	230	165	554	210	634
3875	494	257	218	265	186	706	248	809
3925	547	251	219	271	186	775	268	875
3975	604	247	218	270	183	823	289	903
4025	655	249	222	275	185	870	314	938
4075	644	235	212	264	177	844	316	902
4125	624	222	202	251	168	811	312	861
4175	609	213	194	242	162	785	306	831
4225	599	205	188	234	157	765	303	808
4275	582	196	180	225	149	736	295	776
4325	568	188	173	216	143	712	290	749
4375	556	181	167	208	138	689	284	724
4425	543	174	160	200	133	667	279	699
4475	531	167	155	193	128	646	275	677
4525	518	160	149	186	123	625	270	654
4575	507	154	144	180	119	606	265	634
4625	496	148	139	174	114	589	261	616
4675	484	143	134	169	110	569	255	596
4725	470	137	129	162	105	548	249	575
4775	455	131	124	156	102	529	242	554
4825	442	126	119	150	981–4	512	236	536
4875	432	123	116	146	955	499	233	524
4925	423	119	113	142	928	487	228	510
4975	410	115	109	137	895	471	222	494
5025	398	111	105	132	864	458	216	478
5075	387	107	101	128	836	445	212	464
5125	376	103	981–4	123	808	432	207	450
5175	366	994–4	953	119	782	420	202	436
5225	357	961	926	116	758	409	198	424
5275	349	932	901	112	735	399	194	412
5325	343	905	878	109	715	390	192	403
5375	335	874	853	106	692	379	188	392
5425	327	845	828	103	671	370	185	382
5475	320	818	802	100	650	360	181	371
5525	312	791	776	971–4	628	349	177	359
5575	309	775	761	945	613	342	176	353
5625	302	749	737	911	592	331	172	343
5675	295	725	716	884	575	322	168	334
5725	290	707	697	861	559	314	166	326
5775	283	680	676	837	541	305	162	318
5825	278	661	659	818	528	299	160	311
5875	270	635	635	790	509	290	155	301
5925	262	613	615	765	492	282	152	292

Table 2. Continued

	BS553	*BS1790*	*BS1791*	*BS3982*	*BS5191*	*BS7001*	*BS7557*	*BS8781*
5975	255	595	598	744	475	274	148	285
6025	248	576	580	723	459	266	145	277
6075	242	562	565	708	445	260	143	270
6125	236	546	550	692	431	254	140	264
6175	230	530	535	675	417	247	137	257
6225	224	513	521	657	404	240	134	250
6275	219	500	510	642	394	235	131	245
6325	214	487	499	626	383	229	129	240
6375	211	480	493	618	377	226	127	236
6425	206	468	481	603	368	220	125	230
6475	201	454	466	586	356	215	122	223
6525	197	442	453	573	347	210	120	218
6575	193	432	443	562	339	206	119	213
6625	189	422	434	550	330	202	117	209
6675	186	413	426	539	323	197	116	205
6725	184	405	420	530	317	193	115	201
6775	180	395	412	519	309	189	113	197
6825	176	384	402	505	300	184	110	192
6875	171	373	391	491	291	179	108	186
6925	167	362	381	478	283	175	106	180
6975	165	356	374	471	278	172	105	177
7025	163	350	368	463	273	169	103	174
7075	161	342	361	452	267	164	101	170
7125	158	333	352	440	260	160	987–4	166
7175	154	324	343	428	254	157	969	160
7225	152	317	335	419	249	154	954	157
7275	149	309	326	408	242	150	935	153
7325	146	301	317	398	236	147	917	149
7375	144	295	309	389	230	144	905	146
7425	142	288	301	381	225	141	982	142
7475	139	281	293	373	221	138	876	139
7525	136	274	285	364	216	135	858	135

5 ENERGY DISTRIBUTION DATA

Energy distribution, data of the programme stars in the range 3425–7525Å are presented in Table 3 in erg/cm^2 s cm. Numbers like 219–6 mean 219×10^{-6}.

Table 4 demonstrates the dependence of the mean inner accuracy of spectrophotometric data on wavelength for programme stars. As for the data presented in Paper 1 the mean inner accuracy value is about 2% in the ultraviolet, 1% in the visual and red ranges and 1.5–2% in the region of $\lambda > 7000$Å.

6 SYNTHETIC $B - V$ INDICES

Table 5 contains photometric data and spectral types for five common stars of our programme and the *WBVR* catalogue. This catalogue (Kornilov *et al.*, 1991),

Table 3. The energy distribution of standard stars (erg cm^{-2} s^{-1} cm^{-1}). Numbers like 219–6 mean 219×10^{-6}

	HD896	*HD1094*	*HD18031*	*HD26141*	*HD27887*	*HD68933*	*HD83616*	*HD94118*
3425	219–6	293–6	404–6	259–6	192–6	259–6	127–6	315-6
3475	218	295	402	259	191	259	127	309
3525	222	293	396	263	193	265	133	313
3575	222	299	398	258	204	264	132	308
3625	233	302	404	262	199	272	139	301
3675	249	323	425	260	213	300	154	303
3725	257	337	440	272	217	293	155	313
3775	274	361	496	334	225	304	157	393
3825	314	397	542	444	254	337	166	517
3875	371	428	597	525	274	354	176	610
3925	371	414	576	538	256	342	172	622
3975	410	462	638	600	275	374	200	688
4025	470	551	728	685	336	470	262	804
4075	420	518	658	563	325	460	264	655
4125	429	530	674	577	329	477	272	668
4175	454	546	699	641	338	487	273	743
4225	450	548	691	629	336	481	270	730
4275	436	523	661	600	320	455	249	692
4325	365	476	586	426	290	428	248	494
4375	413	524	649	525	317	470	268	605
4425	425	524	668	552	330	493	280	651
4475	422	541	667	544	330	502	291	651
4525	420	548	657	531	331	511	292	616
4575	412	549	655	515	330	504	292	590
4625	410	543	641	504	330	506	295	590
4675	402	532	632	488	323	493	287	572
4725	393	527	619	470	320	487	289	550
4775	384	528	610	449	314	487	292	528
4825	349	500	572	383	298	463	283	451
4875	325	470	540	341	284	438	271	402
4925	360	502	581	409	301	460	281	479
4975	356	500	576	407	296	456	278	477
5025	351	487	563	399	292	452	276	468
5075	347	480	554	391	291	449	277	455
5125	334	473	543	379	287	437	271	442
5175	325	459	534	368	276	423	264	422
5225	323	464	527	361	277	430	265	413
5275	318	458	520	354	276	432	267	406
5325	313	455	516	346	276	431	271	395
5375	310	454	506	338	272	426	269	387
5425	307	444	500	332	268	426	266	381
5475	303	437	491	322	267	420	269	370
5525	294	435	482	317	261	418	263	361
5575	295	436	482	314	259	415	257	354
5625	288	427	472	303	256	412	257	346
5675	281	425	466	295	254	412	254	337
5725	280	423	460	288	253	410	252	331
5775	277	419	457	282	250	407	253	323
5825	273	415	447	276	248	404	252	316
5875	266	406	440	268	244	396	248	306
5925	261	397	430	264	239	386	244	298

Table 3. Continued

	HD896	*HD1094*	*HD18031*	*HD26141*	*HD27887*	*HD68933*	*HD83616*	*HD94118*
5975	254	390	423	256	235	380	240	288
6025	247	385	418	248	231	373	237	277
6075	244	379	409	241	225	365	232	268
6125	239	368	401	233	223	350	225	254
6175	235	360	394	224	220	344	223	242
6225	231	357	392	227	216	349	226	247
6275	232	352	385	224	218	350	227	245
6325	230	345	384	218	214	344	222	241
6375	223	344	379	216	215	350	222	239
6425	222	334	370	209	213	340	220	228
6475	218	337	367	202	206	337	214	222
6525	212	336	358	189	205	338	217	202
6575	187	301	331	163	188	304	202	178
6625	209	323	351	194	201	330	209	208
6675	205	316	352	192	202	329	211	209
6725	203	316	346	188	202	322	213	205
6775	202	312	345	188	199	321	211	200
6825	198	307	336	184	192	318	209	193
6875	194	303	329	179	193	316	204	189
6925	191	298	327	177	192	312	199	185
6975	186	297	231	174	190	306	199	180
7025	185	295	319	170	188	305	197	179
7075	185	290	315	167	183	305	196	174
7125	180	288	308	165	182	297	192	170
7175	173	283	304	160	176	293	188	170
7225	170	282	299	152	171	291	183	161
7275	170	275	295	146	166	287	181	157
7325	163	275	293	142	167	279	179	155
7375	165	272	288	137	163	274	175	156
7425	163	271	291	134	161	268	176	151
7475	156	264	281	132	159	266	175	145
7525	157	266	280	126	158	262	173	146

	HD99233	*HD124986*	*HD140320*	*HD147062*	*HD153015*	*HD160488*	*HD196218*	*HD197573*
3425	179–6	234–6	187–6	179–6	355–6	197–6	264–6	389–6
3475	178	232	186	182	352	200	261	375
3525	181	237	190	189	360	207	266	373
3575	183	240	190	188	355	208	268	376
3625	187	235	188	193	350	216	273	377
3675	193	256	200	202	368	231	298	388
3725	191	256	202	208	389	235	301	401
3775	195	267	228	207	461	257	309	479
3825	206	300	259	214	555	294	326	608
3875	222	310	270	220	632	324	355	720
3925	214	295	255	218	646	294	330	759
3975	234	308	267	272	686	333	380	872
4025	286	381	325	340	793	340	469	100–5
4075	277	384	319	330	736	377	442	817–6
4125	284	382	318	335	739	384	454	839
4175	284	391	328	336	792	394	464	948

Table 3. Continued

	HD99233	*HD124986*	*HD140320*	*HD147062*	*HD153015*	*HD160488*	*HD196218*	*HD197573*
4225	273	385	329	332	785	388	459	939
4275	253	365	318	294	745	366	427	885
4325	258	331	284	314	603	348	414	636
4375	270	360	304	332	676	381	448	771
4425	288	380	318	352	721	392	472	834
4475	292	395	326	376	711	396	470	816
4525	293	392	323	366	710	397	480	801
4575	294	388	318	369	686	401	476	780
4625	296	389	318	373	690	403	475	766
4675	293	380	310	360	672	398	464	742
4725	290	375	306	358	653	396	457	717
4775	289	373	302	361	631	392	457	681
4825	282	356	285	349	566	373	436	581
4875	273	338	268	331	508	354	414	516
4925	282	356	285	349	572	382	438	618
4975	279	354	286	346	580	378	431	622
5025	276	350	283	342	568	372	425	610
5075	275	349	282	343	562	372	424	597
5125	268	343	276	328	550	361	414	578
5175	258	327	265	319	530	354	403	560
5225	261	330	264	323	526	352	404	549
5275	265	328	262	331	515	356	405	535
5325	264	330	262	331	508	355	406	524
5375	261	328	259	324	503	352	401	511
5425	263	322	257	331	492	356	400	498
5475	263	324	256	328	488	349	398	491
5525	256	316	250	323	477	351	394	480
5575	255	316	250	320	472	343	386	471
5625	255	310	243	316	462	344	382	456
5675	253	305	240	315	450	334	375	444
5725	252	305	240	318	444	339	376	435
5775	251	303	238	317	436	337	372	426
5825	249	299	235	318	430	335	370	416
5875	242	294	230	309	419	326	362	405
5925	239	289	225	303	407	321	355	396
5975	237	283	220	297	402	314	350	386
6025	231	277	214	292	394	308	347	375
6075	224	270	208	285	383	300	344	369
6125	220	257	199	270	374	288	334	359
6175	219	252	187	262	368	281	330	350
6225	217	254	194	269	363	284	327	341
6275	215	253	197	269	354	284	326	335
6325	214	252	195	265	346	284	323	329
6375	214	247	192	268	345	284	321	324
6425	213	242	186	267	338	280	319	317
6475	208	240	187	264	330	272	314	310
6525	210	237	182	257	320	269	310	285
6575	194	219	172	244	278	251	290	245
6625	205	239	180	258	310	269	303	293
6675	203	236	180	257	306	270	306	289
6725	199	233	178	251	301	267	301	282

Table 3. Continued

	HD99233	*HD124986*	*HD140320*	*HD147062*	*HD153015*	*HD160488*	*HD196218*	*HD197573*
6775	194	231	174	249	296	265	297	277
6825	194	226	170	243	285	256	291	269
6875	190	223	166	239	279	250	287	264
6925	190	220	165	238	278	250	285	261
6975	189	214	162	232	272	245	281	256
7025	187	212	162	233	268	246	277	241
7075	185	212	162	230	260	245	273	243
7125	180	209	158	224	252	242	267	237
7175	175	201	154	221	245	243	262	229
7225	173	199	153	218	244	234	255	224
7275	173	197	151	217	234	229	255	221
7325	170	198	147	217	230	226	252	223
7375	169	193	144	209	227	224	252	217
7425	166	190	143	207	228	224	248	212
7475	161	192	139	207	225	218	247	203
7525	160	189	136	203	222	216	245	199

	HD198334	*HD198920*	*HD209665*	*HD211784*	*HD213234*	*HD225054*
3425	163–6	139–6	396–6	201–6	174–6	100–6
3475	162	135	389	207	178	992–7
3525	165	140	379	211	176	102–6
3575	165	140	378	213	175	107
3625	169	145	380	215	176	106
3675	181	169	389	228	182	121
3725	177	172	412	251	183	132
3775	181	196	507	307	208	143
3825	194	220	670	398	267	159
3875	203	249	786	471	324	174
3925	187	278	865	507	359	173
3975	222	310	925	533	396	176
4025	280	365	996	606	451	219
4075	277	353	892	569	393	230
4125	288	354	866	556	386	234
4175	291	371	953	603	431	246
4225	282	381	949	604	443	254
4275	258	380	910	581	424	253
4325	256	332	696	468	320	231
4375	276	368	768	508	356	254
4425	291	392	827	546	395	259
4475	294	402	812	543	389	268
4525	295	411	790	538	387	277
4575	296	408	765	525	377	279
4625	292	411	747	521	370	283
4675	286	400	725	510	360	286
4725	283	396	702	500	349	288
4775	284	397	672	486	335	288
4825	272	378	588	440	292	277
4875	260	357	521	397	258	259
4925	276	384	600	446	300	274
4975	273	385	602	451	306	277

Table 3. Continued

	HD198334	*HD198920*	*HD209665*	*HD211784*	*HD213234*	*HD225054*
5025	269	380	588	443	299	274
5075	267	376	575	435	292	272
5125	259	368	559	427	288	267
5175	255	359	541	411	276	260
5225	254	362	530	406	271	263
5275	254	361	517	398	267	259
5325	254	366	507	394	263	264
5375	251	365	496	390	257	266
5425	253	360	482	383	250	262
5475	248	356	473	378	247	263
5525	248	353	460	370	238	260
5575	246	353	454	367	237	264
5625	238	353	442	356	230	262
5675	237	351	432	349	225	260
5725	236	349	422	341	221	260
5775	235	347	412	336	218	262
5825	235	346	401	331	214	260
5875	228	340	390	322	209	254
5925	223	335	377	314	202	248
5975	220	333	370	309	200	247
6025	220	331	362	304	197	243
6075	217	327	354	297	192	240
6125	214	320	346	290	186	234
6175	211	314	338	281	181	226
6225	204	312	330	278	178	227
6275	201	308	324	275	177	226
6325	200	306	318	272	172	221
6375	201	306	313	268	171	221
6425	199	303	303	263	166	215
6475	197	301	300	253	160	220
6525	192	300	283	244	151	214
6575	181	277	233	208	128	197
6625	194	296	279	243	152	214
6675	193	296	273	245	150	215
6725	190	294	269	243	150	215
6775	188	291	266	237	147	215
6825	184	287	261	233	145	210
6875	178	282	254	226	142	205
6925	176	280	245	223	138	201
6975	174	278	240	219	135	200
7025	172	272	235	215	132	198
7075	171	266	230	213	130	195
7125	165	264	227	207	126	199
7175	166	258	223	202	123	196
7225	163	257	215	200	118	191
7275	163	252	210	192	116	188
7325	159	246	204	191	112	185
7375	158	247	203	189	112	181
7425	156	240	197	184	108	182
7475	156	242	187	177	109	178
7525	156	240	184	178	107	182

Table 4. Mean inner accuracy of energy distribution data (%)

3425	2.4	4125	1.1	4825	0.8	5525	0.6	6225	0.9	6925	1.3
3475	2.1	4175	0.9	4875	0.9	5575	0.7	6275	1.0	6975	1.3
3525	1.8	4225	0.9	4925	0.8	5625	0.7	6325	1.0	7025	1.3
3575	1.7	4275	1.0	4975	0.7	5675	0.8	6375	0.9	7075	1.4
3625	1.7	4325	1.1	5025	0.6	5725	0.8	6425	1.2	7125	1.5
3675	1.6	4375	1.0	5075	0.7	5775	0.7	6475	1.1	7175	1.8
3725	1.7	4425	0.8	5125	0.8	5825	0.7	6525	1.3	7225	1.8
3775	2.0	4475	0.7	5175	0.8	5875	0.7	6575	1.3	7275	1.9
3825	1.6	4525	0.7	5225	0.7	5925	0.8	6625	1.0	7325	1.8
3875	1.7	4575	0.8	5275	0.7	5975	0.9	6675	1.1	7375	1.8
3925	1.8	4625	0.6	5325	0.7	6025	0.8	6725	1.0	7425	2.1
3975	2.1	4675	0.7	5375	0.8	6075	0.8	6775	1.1	7475	2.1
4025	1.5	4725	0.8	5425	0.7	6125	0.8	6825	1.4	7525	2.2
4075	1.0	4775	0.7	5475	0.8	6175	0.9	6875	1.6		

produced on the basis of observations at the Tien'–Shan' High-mountain Station, includes 13 586 northern sky stars brighter than 7.2 mag with declination more than $-14°$. The observations were produced near Alma-Ata (Kazakhstan) at an altitude of 2800 m above sea level. Besides V magnitudes and $W-B$, $B-V$, $V-R$ colour indices the catalogue includes information on the accuracy of observations – the so called "class of accuracy", marked as C ($C = 1$ approximately corresponds to an accuracy of 0.001 mag of average magnitudes at W, B, V and R bands, $C = 2$ to 0.002 mag, and so on). Spectral types are taken from the *WBVR* catalogue.

The fifth column of Table 5 contains synthetic $B-V$ colour indices calculated on the basis of the energy distribution data from Table 3 and the response curves for the B and V bands from *WBVR* catalogue. It was not possible to obtain synthetic $W-B$ and $V-R$ indices because of the absence of measurements in the ultraviolet up to 3000Å and in the near infrared up to 9000Å where response curves of W and R bands differ from zero.

A value of $C_{\text{int}} = 0.620$ for the integration constant was taken (Kharitonov *et al.*, 1994). This value is the mean for four sets of bright stars with reliable energy distribution data. Observed $B-V$ colour indices for these stars of Table 5 were taken from the *WBVR* catalogue.

Table 5. Observed and synthetic $B-V$ colour index

HD	*Sp*	*V*	$(B-V)$	$(B-V)syn$	*C*
18031	F2	7.216	0.380	0.342	4
94118	A3V	7.472	0.080	0.070	2
153015	A5	7.237	0.256	0.242	2
197573	A2	7.173	0.129	0.112	4
209665	A0	7.221	0.056	0.056	2

The mean difference between the observed and synthetic $B-V$ indices for five stars common to the *WBVR* catalogue and our spectrophotometric programme is 0.016 mag.

As in the case of the programme stars of Paper 1 this difference is due mainly to the α Lyr calibration used.

7 CONCLUSION

The energy distribution data for stars presented in Table 3 were obtained with a mean inner accuracy of about 1% in the range 4000–6000Å. Only in the ultraviolet and near infrared edges of the spectrum did the error slightly increase but its mean value does not exceed 2.4%.

Comparision with *WBVR* photometry produced in the place with better seeing and height about 3000 m shows that differences in $B-V$ for common stars do not exceed $0^{m}.02$. Comparison of synthetic and observed $B-V$ indices demonstrates good agreement between spectrophotometry and photometry.

The reliability of energy distribution data makes it possible to use these stars as spectrophotometric standards.

Acknowledgements

We express our gratitude to L. S. Shenavrina for help in preparing this paper. The paper was prepared partly with the support of the ESO C&EE Program (grant A–02–010).

References

Biryukov, V. V., Borisov, G. V., Glushneva, I. N., and Shenavrin, V. I. (1998) *Astron. Astrophys. Trans.* **16**, 83.

Glushneva, I. N., Kharitonov, A. V., Knyazeva, L. N., and Shenavrin, V. I. (1992) *Astron. Astrophys. Suppl. Ser.* **92**, 1.

Hayes, D. S. (1985) In: D. S. Hayes, L. E. Pasinetti, and A. G. Davis Philip (eds.), *Calibration of Fundamental Stellar Quantities*, IAU Symposium 111, p. 247.

Hirshfeld, A. and Sinnott, R. W. (1982) *Sky Catalogue 2000.0*, Sky Publishing Corporation, Cambridge, Massachusetts.

Kharitonov, A. V., Glushneva, I. N., and Knyazeva, L. N. (1994) *Astron. Zh.* **70**, 657.

Kornilov, V. G., Volkov, I. M., Zakharov, A. I., Kozyreva, V. S., Kornilova, L. N., Krutjakov, A. N., Krylov, A. V., Kusakin, A. V., Leontiev, S. E., Mironov, A. V., Moshkaliov, V. G., Pogrosheva, T. M., Sementsov, V. N., and Khaliullin, Kh. F. (1991) *Trudy Gos. Astron. Inst. Shternberga* **63**, 399 pp.

Nesterov, V. V., Ovchinnikov, A. A., Cherepashchuk, A. M., and Sheffer, E. K. (1990) In: J. H. Lieske and V. K. Abalakin (eds.), *Inertial Coordinate System on the Sky*, IAU Symposium 141, p. 355.

Voloshina, I. B., Glushneva, I. N., Doroshenko, V. T., Kolotilov, E. A., Mossakovskaya, L. V., Ovchinnikov, S. L., and Fetisova, T. S. (1982) I. N. Glushneva (ed.), *Spectrophotometry of Bright Stars*, Nauka, Moscow, 255 pp.

Voroshilov, Yu. V., Kolotilov, E. A., Metlov, V. G., and Sheffer, E. K. (1992) In: Nesterov, V. V., Cherepashchuk, A. M., and Sheffer, E. K. (eds.), *Lomonosov Astrometric Space Experiment*, Moscow University Press, p. 156.