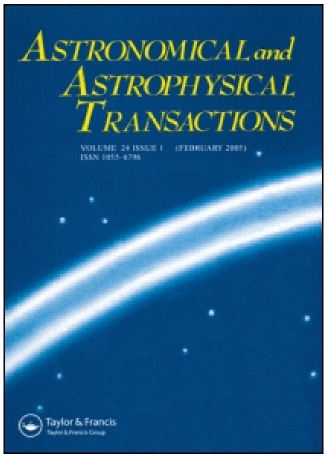

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Spectrophotometric standards of 7-8 MAG

V. V. Biryukov [a]; 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 March 1998
To cite this Article: Biryukov, V. V., Borisov, G. V., Glushneva, I. N. and Shenavrin, V. I. (1998) 'Spectrophotometric standards of 7-8 MAG', Astronomical & Astrophysical Transactions, 16:2, 83 - 103
To link to this article: DOI: 10.1080/10556799808208148
URL: http://dx.doi.org/10.1080/10556799808208148

Astronomical and Astrophysical Transactions, 1998,
Vol. 16, pp. 83–103
Reprints available directly from the publisher
Photocopying permitted by license only

SPECTROPHOTOMETRIC STANDARDS OF 7–8 MAG

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

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

(Received October 7, 1996)

Energy distribution data for 60 stars of spectral type A0–G2 are presented in the range 3425–7525Å in 50Å steps. The mean internal accuracy of the obtained energy distribution data is about 2% in the ultraviolet, 1% in the visual range and 1.5–2% for $\lambda > 7000$Å. Comparison of synthetic $B - V$ indices calculated on the basis of energy distribution data and observed data demonstrates good agreement between spectrophotometry and *WBVR* photometry. These stars may be used as secondary spectrophotometric standards.

KEY WORDS **Spectrophotometry, photometry, stars**

1 INTRODUCTION

The main features of stellar spectrophotometric standards are the reliability of energy distribution data and the absence of monochromatic flux variations exceeding the accuracy of the spectrophotometry. The aim of this investigation is to obtain reliable spectrophotometric data for a set of A0–G2 stars of 7–8 mag.

The creation of two large spectrophotometric catalogues (Voloshina *et al.*, 1982; Kharitonov *et al.*, 1988) at the Sternberg State Astronomical Institute (SSAI) and the Fessenkov Astrophysical Institute (FAI) made it possible to select 238 common stars of different spectral types and luminosities with the best agreement in their energy distribution data (Glushneva *et al.*, 1992). The observations were made in different times and places: at the Crimean Station of the SSAI and at the FAI (Alma-Ata, Kamenskoye Plato). Equipment of the same type and the same methods of correction of the data were used by both groups of investigators.

The absence of systematic differences exceeding the internal accuracy of the energy distribution data obtained for these stars at the SSAI and FAI gave us a chance of using the mean results. These stars may be considered as secondary spectrophotometric standards. However all these stars are brighter than 6 mag and so new reliable spectrophotometric data for fainter stars are very desirable and urgent.

2 OBSERVATIONAL PROGRAMME

Observations of fainter spectrophotometric standards were begun at the SSAI Crimean Station as part of the preparation for the space project Lomonosov (Nesterov *et al.*, 1990). This project includes not only a large number of astrometric measurements but also photometry and spectrophotometry of 10–12 mag stars. A set of spectrophotometric standards is necessary for this work and as a first stage observations of 7–8 mag stars in the zone ±40° relative to the ecliptic were planned.

The criteria and method of choice of the 7–8 mag stars of A0–G2 spectral types are presented in the paper by Voroshilov *et al.* (1992). These stars are not members of the General Catalogue of Variable Stars (fourth edition) or the New Catalogue of Suspected Variable Stars. In this paper we present energy distribution data for 60 stars in the range 3425–7525Å with 50Å steps. The list of programme stars is presented in Table 1.

Table 1. List of stars proposed as secondary spectrophotometric standards

HD 334	HD 16261	HD 68903	HD 154796	HD 199999
HD 1352	HD 18579	HD 78422	HD 154892	HD 203401
HD 1832	HD 18881	HD 83792	HD 155193	HD 210733
HD 7193	HD 19521	HD 88046	HD 162772	HD 213575
HD 7805	HD 20127	HD 92558	HD 163750	HD 214435
HD 11088	HD 20772	HD 99122	HD 168481	HD 215012
HD 11170	HD 21405	HD 109029	HD 171888	HD 215043
HD 12831	HD 21438	HD 145229	HD 179874	HD 217650
HD 12889	HD 28138	HD 145891	HD 181382	HD 218331
HD 14606	HD 36150	HD 146102	HD 183936	HD 218538
HD 14338	HD 50520	HD 153376	HD 196203	HD 219476
HD 15607	HD 59975	HD 154581	HD 198554	HD 221026

3 EQUIPMENT AND METHOD OF CORRECTION

Registration of stellar spectra was done by means of the photoelectric spectrophotometer installed at the 60-cm reflector Zeiss-600 of the SSAI Grimean Station. A grating with discrete scanning and a photomultiplier working in the photon counting regime were used. Tests of the amplifier demonstrated its high stability. The deviation from linearity did not exceed 0.5% at a counting speed of 3×10^5 counts s^{-1}.

Wavelength calibration was done using hydrogen Balmer lines and the telluric O_2 line at 7610Å. As a result the value of the scanning step equal to 47.61Å and the wavelength interval 3380–7617Å were determined.

In these observations the spectral width of the entrance slit was 50Å and inlet diaphragm of 27.5 arcsec 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 following scheme: standard star, programme star, background, program star again and standard star. The stars of the observational programme were compared with standard stars by means of the method of equal altitudes. Differential extinction was taken into account with the spectral extinction coefficient obtained on each observational night. Spectra of two standard stars with differences in air mass not less than 0.5 were registered several times on the night. To reduce the flux from bright standard stars the main mirror of the telescope was stopped by the diaphragm and only half of the mirror surface was opened. For the brightest standards this was not sufficient and in this case the Cassegrain mirror was additionally stopped.

Observational data were input to computer memory and using the graphic regime a continuum was produced in the region of the Balmer lines of the spectra of standard stars. Then the energy distribution in the spectrum of the programme star was calculated using the slandard star spectrum nearest to the time of registration of the programme star. The background and spectral extinction coefficient of the night of observations were taken into account.

Mean energy distribution data were obtained for each 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.

Because of the inconvenience of operating with energy distribution data in an instrumental wavelength system the mean energy distribution was recalculated in 50Å steps beginning at 3425Å.

4 STANDARD STARS

Eight bright stars spread across the sky more or less uniformly 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 both the SSAI and FAI catalogues. Their spectral energy distribution data in 100Å steps are presented in the paper by Glushneva *et al.* (1992). For convenience we present here monochromatic fluxes of standard stars with the same steps and at the same wavelengths, beginning at 3425Å, as for programme stars (Table 2). All the data of Table 2 are reduced to the scale of the Vega energy distribution based on the data obtained by Hayes (1985).

Table 2. The energy distribution of standard stars (erg cm^{-2} s^{-1} cm^{-1})

λ(Å)	β *Ari*	γ *Ori*	β *Tau*	α *Leo*	η *UMa*	α *Lyr*	α *Aql*	α *Peg*
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

Table 2. Continued

$\lambda(Å)$	β *Ari*	γ *Ori*	β *Tau*	α *Leo*	η *UMa*	α *Lyr*	α *Aql*	α *Peg*
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
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

Table 2. Continued

λ(Å)	*β Ari*	*γ Ori*	*β Tau*	*α Leo*	*η UMa*	*α Lyr*	*α Aql*	*α Peg*
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

Table 3 contains the energy distribution data for the programme stars. To transform the data to erg cm^{-2} s^{-1} cm^{-1} they ought to be multiplied by 10^{-6}. Table 4 demonstrates the dependence of the mean internal accuracy of the wavelength for all the stars. The mean 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. The accuracy is higher than in the case of the catalogues of the SSAI and FAI where the mean values are about 3–4%. This gain is obtained by means of work in the photon counting regime while both large catalogues contain data determined on the basis of measurements with the multipliers working in the direct current regime.

Table 3. The energy distribution of stars 10^{-6} (erg cm^{-2} s^{-1} cm^{-1})

λ(Å)	*HD 334*	*HD 1352*	*HD 1832*	*HD 7193*	λ(Å)	*HD 334*	*HD 1352*	*HD 1832*	*HD 7193*
3425	181	338	173	491	5525	265	484	347	651
3475	174	339	175	494	5575	265	476	341	643
3525	182	342	192	508	5625	259	472	337	636
3575	178	343	182	508	5675	256	469	339	635

Table 3. The energy distribution of stars 10^{-6} (erg cm^{-2} s^{-1} cm^{-1})

λ(Å)	HD 334	HD 1352	HD 1832	HD 7193	λ(Å)	HD 334	HD 1352	HD 1832	HD 7193
3625	184	349	192	514	5725	256	468	341	631
3675	195	355	208	538	5775	255	466	342	627
3725	197	358	186	522	5825	255	461	337	618
3775	193	367	179	550	5875	248	452	330	606
3825	219	416	182	595	5925	242	445	329	594
3875	251	447	195	632	5975	239	437	324	585
3925	240	429	203	602	6025	239	429	320	577
3975	271	480	266	691	6075	236	422	316	566
4025	325	578	332	807	6125	230	414	304	554
4075	310	568	337	783	6175	227	402	299	540
4125	318	581	342	807	6225	224	402	300	534
4175	322	594	340	808	6275	222	397	299	528
4225	324	584	328	785	6325	227	395	297	517
4275	306	563	292	759	6375	219	392	298	519
4325	295	532	323	740	6425	218	388	297	513
4375	317	575	331	789	6475	213	379	290	508
4425	323	597	366	791	6525	204	367	285	489
4475	332	605	386	800	6575	198	348	274	472
4525	324	598	382	806	6625	210	368	283	492
4575	327	598	388	810	6675	207	364	284	487
4625	324	587	387	799	6725	205	361	277	481
4675	317	580	378	785	6775	201	352	278	474
4725	315	574	379	781	6825	196	347	275	470
4775	316	566	384	772	6875	189	344	272	463
4825	301	540	372	744	6925	188	337	266	457
4875	287	514	355	719	6975	184	328	260	453
4925	302	548	371	754	7025	181	326	260	449
4975	294	543	366	737	7075	181	324	257	445
5025	290	534	361	726	7125	179	317	251	439
5075	292	532	362	718	7175	175	306	247	426
5125	282	519	346	701	7225	173	310	244	423
5175	276	505	340	692	7275	167	306	238	415
5225	276	506	343	688	7325	167	296	238	414
5275	279	508	357	689	7375	166	290	229	415
5325	280	506	352	681	7425	159	289	233	404
5375	274	498	345	670	7475	152	285	228	410
5425	273	495	348	664	7525	154	278	226	394
5475	268	490	348	656					

λ(Å)	HD 7805	HD 11088	HD 11170	HD 12831	λ(Å)	HD 7805	HD 11088	HD 11170	HD 12831
3425	143	323	200	200	5525	204	406	396	355
3475	140	312	188	198	5575	205	405	392	353
3525	137	316	205	205	5625	197	391	389	351
3575	143	308	206	208	5675	194	385	386	348
3625	141	315	216	219	5725	194	381	387	349
3675	152	335	237	230	5775	190	374	388	343
3725	165	352	237	232	5825	188	370	390	339
3775	192	408	241	238	5875	184	361	381	334
3825	231	499	245	242	5925	179	352	370	332

Table 3. Continued

λ(Å)	*HD 7805*	*HD 11088*	*HD 11170*	*HD 12831*	λ(Å)	*HD 7805*	*HD 11088*	*HD 11170*	*HD 12831*
3875	255	563	260	251	5975	175	344	366	324
3925	259	581	259	247	6025	171	335	364	319
3975	263	613	309	311	6075	168	328	361	314
4025	304	692	400	386	6125	164	322	351	304
4075	299	638	403	384	6175	159	309	341	298
4125	290	634	418	396	6225	156	309	336	294
4175	312	685	419	397	6275	155	299	336	292
4225	316	681	414	388	6325	154	299	334	288
4275	310	661	383	348	6375	152	298	331	291
4325	258	539	397	355	6425	147	286	333	290
4375	279	602	422	380	6475	145	282	320	285
4425	296	635	439	404	6525	143	268	319	280
4475	293	628	457	420	6575	122	238	304	269
4525	296	619	460	418	6625	143	272	317	278
4575	289	602	460	421	6675	139	266	315	277
4625	288	598	454	416	6725	136	263	310	273
4675	283	588	442	403	6775	134	259	305	270
4725	279	572	448	408	6825	132	254	297	263
4775	271	551	454	408	6875	129	245	292	259
4825	248	493	443	389	6925	128	248	291	256
4875	224	453	420	369	6975	126	241	290	251
4925	246	508	439	394	7025	125	239	284	249
4975	249	507	428	389	7075	123	234	279	248
5025	241	493	420	382	7125	120	224	283	248
5075	238	488	423	383	7175	117	217	271	242
5125	233	479	408	369	7225	115	216	270	236
5175	224	462	404	366	7275	112	215	272	232
5225	222	451	406	365	7325	113	211	267	230
5275	216	441	412	371	7375	112	207	263	229
5325	217	436	414	370	7425	108	204	256	224
5375	214	430	406	366	7475	106	198	271	223
5425	208	426	405	366	7525	104	200	257	223
5475	208	420	399	360					

λ(Å)	*HD 12889*	*HD 14338*	*HD 14606*	*HD 15607*	λ(Å)	*HD 12889*	*HD 14338*	*HD 14606*	*HD 15607*
3425	126	240	203	177	5525	195	314	298	260
3475	125	237	204	175	5575	192	312	297	256
3525	125	237	204	184	5625	190	305	289	250
3575	128	236	204	181	5675	188	302	285	250
3625	132	248	207	185	5725	186	299	282	246
3675	139	260	215	198	5775	184	293	275	246
3725	152	261	236	208	5825	180	291	269	242
3775	181	281	295	245	5875	177	286	265	235
3825	212	315	371	297	5925	173	283	257	229
3875	237	338	424	327	5975	169	277	250	226
3925	230	313	414	324	6025	165	273	243	220
3975	260	369	476	369	6075	161	268	237	210
4025	301	438	578	420	6125	158	260	231	204
4075	272	407	486	390	6175	155	256	225	200

Table 3. Continued

λ(Å)	HD 12889	HD 14338	HD 14606	HD 15607	λ(Å)	HD 12889	HD 14338	HD 14606	HD 15607
4125	279	420	506	393	6225	151	252	221	206
4175	291	428	553	404	6275	149	250	217	201
4225	288	421	543	400	6325	147	249	210	197
4275	274	394	510	393	6375	145	246	204	197
4325	235	365	383	355	6425	143	240	201	192
4375	264	400	468	388	6475	141	241	197	188
4425	273	414	492	383	6525	137	230	187	178
4475	274	419	488	381	6575	124	215	160	182
4525	272	413	479	368	6625	137	232	186	189
4575	268	409	473	367	6675	135	229	183	184
4625	266	405	465	363	6725	133	229	179	179
4675	264	397	452	355	6775	130	224	178	177
4725	258	391	438	349	6825	127	219	176	171
4775	252	384	422	340	6875	125	216	173	168
4825	231	360	366	318	6925	123	214	167	165
4875	213	343	331	308	6975	122	212	165	164
4925	233	369	385	321	7025	121	209	163	160
4975	231	364	384	314	7075	119	206	160	158
5025	229	358	374	310	7125	117	204	159	155
5075	226	354	364	304	7175	116	202	159	153
5125	221	344	355	296	7225	114	200	156	147
5175	215	332	345	292	7275	111	197	154	144
5225	212	329	337	288	7325	110	195	148	142
5275	208	330	329	283	7375	110	191	148	143
5325	206	328	323	280	7425	109	188	146	139
5375	203	323	318	272	7475	106	187	144	137
5425	202	322	307	271	7525	105	185	143	137
5475	198	315	305	263					

λ(Å)	HD 16261	HD 18579	HD 18881	HD 19521	λ(Å)	HD 16261	HD 18579	HD 18881	HD 19521
3425	284	293	544	372	5525	401	401	501	575
3475	281	287	536	386	5575	396	403	493	566
3525	286	286	523	376	5625	389	391	481	549
3575	290	293	545	383	5675	383	391	464	535
3625	293	297	532	399	5725	376	388	452	537
3675	307	311	541	410	5775	373	386	445	532
3725	320	331	560	436	5825	364	378	427	522
3775	377	373	748	516	5875	354	370	413	505
3825	456	420	988	650	5925	345	364	402	499
3875	529	449	1100	724	5975	338	358	396	485
3925	534	434	1119	683	6025	329	351	384	475
3975	563	441	1151	745	6075	322	345	370	462
4025	656	512	1248	926	6125	314	338	356	448
4075	612	503	1086	835	6175	304	329	348	441
4125	608	509	1099	863	6225	303	323	345	428
4175	656	526	1163	917	6275	299	322	337	424
4225	658	519	1123	920	6325	298	318	337	413
4275	637	504	1075	873	6375	296	316	334	401
4325	521	453	860	723	6425	286	313	325	396

Table 3. Continued

λ(Å)	HD 16261	HD 18579	HD 18881	HD 19521	λ(Å)	HD 16261	HD 18579	HD 18881	HD 19521
4375	581	495	976	834	6475	282	306	312	395
4425	615	416	972	853	6525	266	303	300	370
4475	608	509	964	845	6575	240	273	257	333
4525	599	515	918	846	6625	271	297	297	378
4575	584	507	888	828	6675	267	298	291	374
4625	586	506	866	820	6725	263	295	289	366
4675	571	499	831	803	6775	261	286	281	359
4725	557	496	806	793	6825	255	284	275	358
4775	534	485	766	778	6875	246	278	266	348
4825	483	462	698	713	6925	244	273	262	335
4875	438	439	633	650	6975	243	270	263	333
4925	494	465	704	718	7025	239	268	258	333
4975	496	461	690	698	7075	234	263	249	327
5025	482	453	671	685	7125	228	259	244	325
5075	472	449	650	682	7175	224	256	233	317
5125	460	441	628	663	7225	216	252	233	308
5175	447	428	609	640	7275	212	253	226	304
5225	439	427	593	626	7325	208	248	215	303
5275	437	423	581	618	7375	207	243	218	290
5325	433	422	571	603	7425	205	241	210	292
5375	420	417	547	611	7475	201	237	206	289
5425	415	410	533	590	7525	201	233	196	290
5475	415	407	520	581					

λ(Å)	HD 20127	HD 20772	HD 21405	HD 21438	λ(Å)	HD 20127	HD 20772	HD 21405	HD 21438
3425	215	155	340	164	5525	297	205	400	281
3475	215	153	330	165	5575	294	204	386	279
3525	216	149	325	165	5625	291	197	374	273
3575	217	147	330	167	5675	287	191	366	269
3625	228	151	325	165	5725	287	188	357	266
3675	241	158	333	173	5775	282	184	351	263
3725	243	167	341	198	5825	278	183	342	256
3775	258	196	422	246	5875	274	177	336	249
3825	290	242	534	305	5925	269	173	318	244
3875	306	278	655	348	5975	262	167	309	238
3925	287	273	662	333	6025	258	163	303	234
3975	336	315	739	386	6075	254	159	295	227
4025	402	380	870	462	6125	248	155	285	214
4075	379	322	696	398	6175	243	152	267	206
4125	392	340	755	413	6225	239	147	273	209
4175	400	367	838	442	6275	236	142	272	209
4225	395	364	819	433	6325	233	141	271	207
4275	368	336	753	402	6375	232	139	265	204
4325	339	260	543	323	6425	228	138	253	201
4375	373	320	697	385	6475	225	133	244	196
4425	384	340	724	404	6525	212	118	208	181
4475	388	329	709	404	6575	207	116	215	172
4525	386	319	665	399	6625	218	125	236	188
4575	386	321	659	392	6675	216	124	237	187

Table 3. Continued

λ(Å)	HD 20127	HD 20772	HD 21405	HD 21438	λ(Å)	HD 20127	HD 20772	HD 21405	HD 21438
4625	381	314	646	387	6725	212	124	230	183
4675	373	305	627	380	6775	211	121	228	180
4725	367	296	598	369	6825	204	115	223	177
4775	364	284	551	354	6875	200	112	218	175
4825	341	243	467	314	6925	198	113	215	173
4875	323	225	447	293	6975	195	112	210	171
4925	348	263	524	335	7025	195	113	207	170
4975	344	260	512	333	7075	192	111	202	168
5025	338	254	503	328	7125	187	107	192	165
5075	334	246	494	323	7175	183	102	192	163
5125	328	239	474	315	7225	182	99	181	159
5175	322	233	465	309	7275	180	101	182	156
5225	316	226	451	305	7325	176	102	181	153
5275	315	225	450	300	7375	173	102	177	152
5325	312	222	437	297	7425	171	98	165	149
5375	306	216	418	292	7475	168	93	166	146
5425	305	212	425	290	7525	166	90	162	142
5475	300	207	409	285					

λ(Å)	HD 28138	HD 36150	HD 50520	HD 59975	λ(Å)	HD 28138	HD 36150	HD 50520	HD 59975
3425	224	693	238	326	5525	394	935	374	445
3475	229	664	241	325	5575	396	905	371	442
3525	227	690	241	323	5625	387	897	361	430
3575	224	667	244	324	5675	380	880	356	420
3625	226	664	248	328	5725	376	868	352	415
3675	227	697	261	346	5775	365	860	346	401
3725	262	718	270	372	5825	359	843	338	395
3775	354	859	337	476	5875	355	808	326	382
3825	454	1056	446	622	5925	343	785	316	370
3875	535	1226	491	731	5975	334	767	312	363
3925	548	1201	526	729	6025	331	748	306	350
3975	565	1416	565	817	6075	322	725	296	341
4025	633	1664	654	958	6125	312	685	283	330
4075	556	1394	600	797	6175	311	655	271	318
4125	577	1461	591	818	6225	301	668	275	317
4175	615	1596	653	892	6275	303	688	275	314
4225	604	1565	663	888	6325	302	676	274	309
4275	594	1437	637	836	6375	298	675	270	305
4325	479	1145	489	607	6425	295	661	263	306
4375	554	1379	544	736	6475	285	656	262	294
4425	554	1450	589	782	6525	266	582	248	277
4475	547	1456	593	776	6575	262	588	209	228
4525	537	1399	585	747	6625	276	621	242	274
4575	541	1377	562	721	6675	274	621	244	270
4625	530	1365	561	712	6725	273	611	243	271
4675	529	1318	547	694	6775	276	601	240	268
4725	509	1285	530	671	6825	270	582	237	265
4775	493	1229	512	642	6875	270	563	234	256
4825	449	1083	452	552	6925	265	561	230	248

Table 3. Continued

λ(Å)	HD 28138	HD 36150	HD 50520	HD 59975	λ(Å)	HD 28138	HD 36150	HD 50520	HD 59975
4875	423	1019	402	493	6975	262	550	225	244
4925	476	1170	458	582	7025	258	547	222	243
4975	466	1150	465	577	7075	255	539	217	237
5025	459	1116	457	564	7125	250	516	214	234
5075	450	1100	446	553	7175	248	508	210	229
5125	443	1057	440	537	7225	243	494	207	228
5175	437	1026	423	519	7275	241	481	204	223
5225	431	1004	416	511	7325	239	485	200	212
5275	426	1007	411	500	7375	235	468	196	210
5325	421	1005	400	489	7425	230	462	191	201
5375	411	966	396	478	7475	225	458	188	191
5425	409	958	388	471	7525	221	442	189	188
5475	403	949	383	461					

λ(Å)	HD 68903	HD 78422	HD 83792	HD 88046	λ(Å)	HD 68903	HD 78422	HD 83792	HD 88046
3425	614	257	184	326	5525	428	386	277	477
3475	595	249	180	328	5575	419	377	268	468
3525	591	256	184	331	5625	409	367	265	461
3575	577	252	184	335	5675	398	357	263	457
3625	575	258	193	340	5725	389	359	263	453
3675	583	285	211	370	5775	377	355	257	448
3725	465	308	224	375	5825	360	349	253	441
3775	806	362	259	409	5875	349	342	246	433
3825	964	420	308	473	5925	339	335	242	425
3875	1108	468	359	529	5975	328	329	237	418
3925	1081	461	338	503	6025	317	321	234	412
3975	1112	516	389	560	6075	310	315	230	403
4025	1189	593	482	676	6125	305	309	221	397
4075	1015	545	424	648	6175	296	302	216	392
4125	1012	552	434	658	6225	288	302	212	387
4175	1045	577	459	674	6275	282	300	213	384
4225	1015	574	444	661	6325	278	297	216	381
4275	962	547	420	628	6375	274	297	211	377
4325	780	474	346	564	6425	266	289	210	371
4375	867	524	402	609	6475	261	288	199	366
4425	865	539	414	625	6525	243	273	191	357
4475	845	547	422	638	6575	227	256	178	324
4525	816	535	419	634	6625	242	280	201	356
4575	783	529	409	627	6675	235	277	199	351
4625	759	527	403	624	6725	231	276	198	347
4675	733	522	397	617	6775	225	272	190	342
4725	706	509	385	608	6825	220	269	184	336
4775	674	492	371	598	6875	212	261	176	333
4825	608	454	329	557	6925	210	255	178	326
4875	563	429	302	525	6975	206	252	176	321
4925	613	468	343	559	7025	200	251	175	319
4975	598	461	339	559	7075	194	249	172	314
5025	580	453	339	556	7125	190	239	166	307
5075	561	450	335	550	7175	184	230	161	303

Table 3. Continued

λ(Å)	HD 68903	HD 78422	HD 83792	HD 88046	λ(Å)	HD 68903	HD 78422	HD 83792	HD 88046
5125	542	438	322	533	7225	179	230	158	296
5175	523	418	308	522	7275	174	226	156	291
5225	506	412	301	512	7325	170	224	158	287
5275	497	410	300	608	7375	166	224	153	281
5325	483	405	298	506	7425	164	215	148	278
5375	468	399	293	498	7475	157	217	150	269
5425	457	399	293	494	7525	156	210	149	263
5475	444	392	286	488					

λ(Å)	HD 92558	HL 99122	HD 109029	HD 145229	λ(Å)	HD 92558	HD 99122	HD 109029	HD 145229
3425	162	211	262	255	5525	198	334	371	398
3475	156	207	261	254	5575	194	330	368	395
3525	154	218	264	261	5625	190	323	360	391
3575	154	214	270	259	5675	184	321	355	389
3625	155	217	269	258	5725	181	323	354	383
3675	159	237	285	292	5775	177	321	354	384
3725	174	232	286	309	5825	172	320	348	385
3775	217	249	326	311	5875	167	313	341	375
3825	280	274	378	334	5925	162	306	334	365
3875	343	280	402	309	5975	159	299	325	364
3925	341	259	391	303	6025	154	293	317	360
3975	379	290	406	302	6075	147	286	309	360
4025	446	366	485	387	6125	142	273	294	347
4075	361	363	498	417	6175	137	261	276	345
4125	379	368	479	416	6225	137	268	290	342
4175	416	373	491	424	6275	136	272	292	339
4225	407	366	493	424	6325	133	272	288	334
4275	369	345	475	412	6375	132	271	290	334
4325	271	331	442	379	6425	128	267	281	327
4375	338	359	444	411	6475	123	264	275	327
4425	354	376	471	434	6525	110	257	268	324
4475	351	394	484	450	6575	105	244	247	305
4525	337	385	482	472	6625	117	259	272	321
4575	335	388	470	467	6675	115	255	274	317
4625	329	387	468	467	6725	114	253	265	310
4675	314	379	461	458	6775	111	249	261	305
4725	305	380	457	452	6825	108	242	257	302
4775	290	380	455	450	6875	106	235	251	291
4825	249	366	435	438	6925	104	239	248	286
4875	226	349	414	424	6975	101	234	241	283
4925	266	366	424	430	7025	100	233	241	280
4975	262	361	425	429	7075	97	228	241	276
5025	258	357	419	426	7125	93	224	236	273
5075	252	357	417	425	7175	92	218	232	267
5125	241	347	410	421	7225	91	217	224	261
5175	232	334	393	400	7275	88	218	221	259
5225	224	337	386	404	7325	88	216	218	262
5275	221	341	387	410	7375	86	209	215	251

Table 3. Continued

λ(Å)	HD 92558	HD 99122	HD 109029	HD 145229	λ(Å)	HD 92558	HD 99122	HD 109029	HD 145229
5325	219	342	391	412	7425	83	205	214	256
5375	212	339	389	409	7475	80	203	208	253
5425	208	337	382	406	7525	79	201	202	243
5475	202	336	375	404					

λ(Å)	HD 145891	HD 146102	HD 153376	HD 154581	λ(Å)	HD 145891	HD 146102	HD 153376	HD 154581
3425	408	348	350	241	5525	589	616	676	368
3475	395	349	353	232	5575	578	604	664	368
3525	410	355	356	233	5625	565	600	653	357
3575	399	353	357	236	5675	557	594	653	352
3625	415	371	369	242	5725	551	590	649	346
3675	437	401	383	256	5775	542	588	649	340
3725	488	410	405	276	5825	532	581	646	334
3775	607	433	421	344	5875	520	564	636	323
3825	746	468	419	424	5925	508	561	628	318
3875	819	501	439	475	5975	494	550	615	310
3925	813	483	449	477	6025	484	541	606	302
3975	839	583	514	528	6075	474	530	597	294
4025	971	716	661	620	6125	460	516	583	288
4075	919	687	670	556	6175	448	511	584	281
4125	908	716	702	565	6225	438	499	572	276
4175	964	732	702	619	6275	430	501	572	275
4225	968	724	691	623	6325	430	493	555	271
4275	943	666	638	584	6375	424	491	554	263
4325	783	650	670	473	6425	413	481	540	257
4375	846	699	721	532	6475	403	475	531	250
4425	890	729	752	571	6525	383	461	528	225
4475	877	754	766	572	6575	349	462	502	221
4525	872	739	764	558	6625	393	471	530	243
4575	860	744	781	550	6675	387	465	526	239
4625	847	748	780	539	6725	383	463	523	235
4675	830	730	750	526	6775	371	454	512	236
4725	814	730	757	516	6825	366	443	504	228
4775	789	719	770	495	6875	355	435	506	221
4825	710	676	751	437	6925	346	436	507	218
4875	662	641	727	406	6975	342	423	502	216
4925	732	691	752	460	7025	338	412	492	214
4975	732	675	721	459	7075	329	401	487	205
5025	716	666	703	446	7125	322	392	473	198
5075	703	676	704	442	7175	315	383	476	190
5125	683	650	682	430	7225	308	376	468	188
5175	658	632	673	417	7275	306	373	468	187
5225	647	632	682	407	7325	296	370	459	185
5275	636	640	688	406	7375	289	358	458	178
5325	628	637	698	400	7425	284	361	452	175
5375	627	625	688	391	7475	283	355	449	171
5425	610	623	687	385	7525	270	350	438	164
5475	601	617	674	380					

Table 3. Continued

λ(Å)	HD 154796	HD 154892	HD 155193	HD 162772	λ(Å)	HD 154796	HD 154892	HD 155193	HD 162772
3425	262	181	380	305	5525	382	261	588	341
3475	264	177	381	305	5575	372	256	586	334
3525	267	180	386	308	5625	369	253	584	327
3575	264	182	394	316	5675	365	252	575	318
3625	266	184	405	314	5725	362	251	574	314
3675	279	198	420	300	5775	358	250	573	299
3725	279	197	459	311	5825	351	246	566	293
3775	295	215	470	399	5875	342	241	553	282
3825	319	243	485	539	5925	341	236	543	272
3875	343	246	508	639	5975	337	232	539	267
3925	331	235	527	647	6025	331	230	529	261
3975	400	263	525	669	6075	324	224	525	256
4025	482	313	610	778	6125	316	219	513	254
4075	457	310	653	646	6175	311	217	500	239
4125	473	314	656	683	6225	306	214	496	233
4175	483	323	676	753	6275	305	212	495	229
4225	479	321	676	736	6325	305	210	489	223
4275	436	301	646	727	6375	301	208	490	222
4325	417	286	583	526	6425	296	204	482	214
4375	457	305	636	636	6475	296	201	478	209
4425	468	318	673	648	6525	273	193	479	186
4475	487	324	690	618	6575	286	190	438	166
4525	468	318	718	610	6625	290	196	467	197
4575	476	322	709	590	6675	284	194	461	193
4625	472	318	707	570	6725	282	190	451	191
4675	465	313	691	553	6775	277	191	452	187
4725	458	313	684	531	6825	268	186	440	180
4775	447	310	687	504	6875	262	183	428	178
4825	424	294	668	439	6925	264	179	421	174
4875	405	280	633	399	6975	257	177	416	170
4925	429	295	653	473	7025	254	177	411	170
4975	425	290	652	463	7075	251	173	406	168
5025	419	286	638	448	7125	243	172	398	163
5075	418	286	641	429	7175	239	170	388	157
5125	404	278	633	420	7225	239	168	379	159
5175	396	274	609	412	7275	234	165	371	156
5225	396	272	610	403	7325	233	163	369	145
5275	400	275	603	384	7375	228	158	363	154
5325	397	272	613	379	7425	222	159	361	149
5375	391	269	613	376	7475	224	158	362	143
5425	389	264	601	363	7525	215	154	357	129
5475	387	265	605	348					

λ(Å)	HD 163750	HD 168481	HD 171888	HD 179874	λ(Å)	HD 163750	HD 168481	HD 171888	HD 179874
3425	276	322	401	108	5525	391	605	654	200
3475	257	329	401	110	5575	392	603	636	197
3525	263	324	408	115	5625	392	589	630	199
3575	252	330	406	116	5675	388	582	625	197
3625	269	342	417	114	5725	382	576	625	192

Table 3. Continued

λ(Å)	HD 163750	HD 168481	HD 171888	HD 179874	λ(Å)	HD 163750	HD 168481	HD 171888	HD 179874
3675	287	349	449	127	5775	382	560	620	192
3725	285	398	428	126	5825	379	557	616	191
3775	302	505	440	125	5875	370	547	600	187
3825	328	606	464	126	5925	364	532	596	185
3875	352	711	481	131	5975	351	518	587	183
3925	335	715	478	132	6025	354	507	579	180
3975	364	797	588	152	6075	346	502	569	178
4025	465	967	709	196	6125	339	488	560	176
4075	454	834	703	203	6175	335	475	551	176
4125	475	898	726	213	6225	325	466	536	171
4175	479	957	728	210	6275	323	455	530	169
4225	469	961	721	207	6325	314	444	531	167
4275	457	975	657	197	6375	321	441	530	169
4325	449	764	677	207	6425	316	432	527	167
4375	488	920	718	218	6475	310	426	516	162
4425	483	905	752	225	6525	304	394	493	159
4475	482	893	786	229	6575	276	358	500	154
4525	483	890	761	232	6625	303	403	503	163
4575	493	858	769	231	6675	297	407	502	162
4625	490	840	770	232	6725	296	403	500	159
4675	475	818	742	225	6775	295	395	493	158
4725	470	807	753	225	6825	295	388	479	155
4775	468	786	744	229	6875	292	381	467	155
4825	449	705	710	222	6925	286	373	468	151
4875	435	650	689	213	6975	282	366	459	148
4925	454	750	722	222	7025	274	358	451	147
4975	440	734	706	215	7075	272	356	448	147
5025	433	720	699	210	7125	277	349	441	143
5075	423	712	691	209	7175	270	338	431	138
5125	414	691	668	204	7225	265	335	426	134
5175	408	668	667	203	7275	267	326	422	131
5225	412	648	666	204	7325	265	315	407	129
5275	409	638	678	206	7375	258	316	400	136
5325	402	639	677	205	7425	253	308	401	134
5375	402	628	667	203	7475	246	304	396	131
5425	394	628	663	204	7525	255	299	390	136
5475	395	614	651	200					

λ(Å)	HD 181382	HD 183936	HD 196203	HD 198554	λ(Å)	HD 181382	HD 183936	HD 196203	HD 198554
3425	201	426	320	114	5525	323	603	527	192
3475	205	407	318	103	5575	323	598	529	191
3525	207	428	323	111	5625	322	594	521	186
3575	206	416	322	114	5675	317	585	517	184
3625	210	421	326	115	5725	314	577	515	182
3675	226	448	349	128	5775	311	568	511	180
3725	227	446	362	136	5825	310	567	505	178
3775	244	496	396	155	5875	306	558	498	173
3825	268	565	432	186	5925	301	548	488	169
3875	293	601	466	219	5975	293	540	479	167

Table 3. Continued

λ(Å)	HD 181382	HD 183936	HD 196203	HD 198554	λ(Å)	HD 181382	HD 183936	HD 196203	HD 198554
3925	272	553	440	213	6025	289	528	473	164
3975	303	592	480	232	6075	287	522	464	161
4025	371	736	589	281	6125	280	513	454	158
4075	367	720	607	255	6175	276	512	448	155
4125	382	749	626	266	6225	270	503	438	152
4175	386	766	627	283	6275	266	493	435	149
4225	381	758	626	279	6325	264	484	429	149
4275	372	756	612	270	6375	265	486	430	145
4325	361	708	592	229	6425	259	477	427	142
4375	382	758	634	264	6475	257	467	416	137
4425	383	751	629	263	6525	250	454	409	131
4475	389	751	640	263	6575	236	426	391	126
4525	394	761	635	263	6625	247	460	412	138
4575	388	747	639	261	6675	248	459	408	137
4625	388	753	639	262	6725	249	455	402	136
4675	383	737	630	256	6775	243	450	397	133
4725	379	729	629	249	6825	239	438	391	129
4775	378	717	625	243	6875	236	434	382	126
4825	364	686	604	223	6925	234	424	376	124
4875	352	663	582	209	6975	230	416	375	123
4925	367	700	606	233	7025	228	415	370	119
4975	360	682	590	227	7075	224	415	365	116
5025	353	664	582	223	7125	222	405	357	114
5075	352	657	574	222	7175	219	389	342	112
5125	349	647	564	216	7225	218	394	346	110
5175	341	635	556	209	7275	216	382	340	110
5225	335	634	552	210	7325	213	382	355	108
5275	335	633	554	205	7375	208	378	338	103
5325	339	629	552	201	7425	207	373	326	98
5375	332	625	544	198	7475	206	367	331	94
5425	332	619	545	196	7525	204	368	324	91
5475	330	603	533	194					

λ(Å)	HD 199999	HD 203401	HD 210733	HD 213575	λ(Å)	HD 199999	HD 203401	HD 210733	HD 213575
3425	324	263	366	309	5525	454	422	516	615
3475	318	253	358	321	5575	451	420	510	601
3525	330	260	355	336	5625	447	412	513	595
3575	323	259	358	302	5675	441	408	500	590
3625	332	262	378	346	5725	434	398	493	593
3675	351	272	395	381	5775	431	388	491	597
3725	347	302	395	341	5825	424	382	489	591
3775	377	371	438	324	5875	418	373	472	576
3825	428	477	500	313	5925	409	364	459	577
3875	465	580	563	352	5975	402	356	449	570
3925	437	576	533	380	6025	396	348	445	566
3975	478	626	578	462	6075	390	342	441	554
4025	580	753	691	573	6125	382	333	431	544
4075	557	633	650	585	6175	377	326	428	542
4125	582	668	689	604	6225	367	316	415	536

Table 3. Continued

λ(Å)	HD 199999	HD 203401	HD 210733	HD 213575	λ(Å)	HD 199999	HD 203401	HD 210733	HD 213575
4175	596	730	719	595	6275	365	313	403	531
4225	588	722	716	568	6325	357	310	404	532
4275	576	703	695	522	6375	350	305	403	531
4325	536	530	622	554	6425	348	300	396	531
4375	589	644	701	585	6475	340	287	385	516
4425	582	657	693	612	6525	328	269	377	509
4475	580	654	702	654	6575	308	243	357	497
4525	576	641	678	658	6625	332	275	380	516
4575	575	623	674	663	6675	331	272	376	509
4625	574	617	675	671	6725	329	271	371	508
4675	560	599	659	657	6775	322	264	372	507
4725	553	582	651	655	6825	319	259	355	498
4775	545	559	635	658	6875	314	256	347	481
4825	517	493	597	650	6925	307	249	341	475
4875	503	455	570	634	6975	304	246	333	468
4925	530	531	621	647	7025	304	242	332	469
4975	515	523	606	639	7075	296	237	332	460
5025	510	512	596	629	7125	291	237	319	456
5075	500	499	584	625	7175	288	232	315	433
5125	488	486	566	607	7225	284	228	312	429
5175	482	476	563	595	7275	279	227	304	430
5225	479	472	557	608	7325	276	218	297	436
5275	477	462	555	624	7375	270	214	304	426
5325	473	456	545	624	7425	265	207	295	423
5375	467	448	539	612	7475	267	204	301	426
5425	461	442	532	616	7525	262	208	284	397
5475	461	432	525	624					

λ(Å)	HD 214435	HD 215012	HD 215043	HD 217650	λ(Å)	HD 214435	HD 215012	HD 215043	HD 217650
3425	171	398	282	129	5525	264	384	408	188
3475	170	397	273	129	5575	259	377	397	186
3525	174	390	281	133	5625	254	367	392	186
3575	175	390	280	129	5675	253	361	383	185
3625	177	389	278	136	5725	254	354	374	183
3675	185	390	292	143	5775	255	346	366	182
3725	185	402	303	141	5825	252	339	358	181
3775	183	464	358	145	5875	245	328	346	177
3825	191	599	457	168	5925	241	319	339	175
3875	217	722	557	188	5975	240	313	334	170
3925	220	735	563	180	6025	236	307	324	166
3975	242	778	637	204	6075	233	299	317	165
4025	286	887	755	243	6125	229	293	311	162
4075	277	739	633	230	6175	227	288	306	158
4125	283	761	663	238	6225	224	280	309	159
4175	287	809	722	243	6275	225	274	298	156
4225	285	787	717	240	6325	223	265	299	156
4275	274	739	673	231	6375	223	266	294	154
4325	260	564	522	218	6425	216	262	284	150
4375	281	670	639	236	6475	217	255	276	147

Table 3. Continued

λ(Å)	HD 214435	HD 215012	HD 215043	HD 217650	λ(Å)	HD 214435	HD 215012	HD 215043	HD 217650
4425	299	691	651	237	6525	211	238	252	147
4475	302	662	654	242	6575	200	226	237	132
4525	306	650	628	236	6625	210	237	263	144
4575	306	629	620	237	6675	206	238	265	142
4625	305	619	610	236	6725	205	235	264	140
4675	295	598	596	231	6775	201	229	255	137
4725	296	580	576	228	6825	198	226	247	134
4775	298	556	550	225	6875	197	221	242	132
4825	290	489	481	212	6925	194	214	237	131
4875	279	453	447	203	6975	192	210	231	129
4925	288	515	518	217	7025	189	209	225	127
4975	286	507	510	213	7075	184	203	222	124
5025	286	493	499	211	7125	182	194	221	122
5075	283	479	492	210	7175	180	188	217	121
5125	278	464	475	204	7225	175	187	207	119
5175	268	449	456	201	7275	174	182	204	120
5225	271	440	443	198	7325	172	176	197	117
5275	271	432	442	199	7375	169	174	186	116
5325	274	423	438	198	7425	167	168	186	115
5375	267	415	427	194	7475	164	164	191	113
5425	263	406	422	193	7525	164	164	181	110
5475	263	393	416	190					

λ(Å)	HD 218331	HD 218538	HD 219476	HD 221026	λ(Å)	HD 218331	HD 218538	HD 219476	HD 221026
3425	336	252	207	243	5525	392	369	329	411
3475	316	247	206	253	5575	390	365	327	404
3525	310	252	214	260	5625	387	352	322	401
3575	311	250	215	257	5675	372	343	321	395
3625	322	254	217	267	5725	354	338	320	396
3675	333	262	239	270	5775	345	330	321	394
3725	348	285	234	274	5825	342	324	317	388
3775	421	347	238	286	5875	334	315	309	381
3825	503	454	265	321	5925	321	308	304	379
3875	641	556	281	353	5975	314	303	301	371
3925	655	587	270	342	6025	307	296	297	365
3975	696	653	288	412	6075	299	288	292	358
4025	827	747	349	491	6125	289	280	289	346
4075	676	631	358	474	6175	283	274	284	341
4125	729	643	364	484	6225	277	268	281	339
4175	818	702	367	496	6275	267	264	281	340
4225	814	695	361	495	6325	264	258	281	336
4275	749	658	340	455	6375	254	256	278	339
4325	536	493	324	442	6425	250	249	274	326
4375	688	586	348	472	6475	242	241	272	326
4425	693	622	366	489	6525	213	227	268	316
4475	695	615	374	515	6575	210	196	251	305
4525	662	598	376	496	6625	240	229	265	320
4575	649	581	375	499	6675	234	227	260	314
4625	635	575	376	498	6725	224	223	258	312

Table 3. Continued

λ(Å)	*HD 218331*	*HD 218538*	*HD 219476*	*HD 221026*	λ(Å)	*HD 218331*	*HD 218538*	*HD 219476*	*HD 221026*
4675	610	558	373	484	6775	221	219	253	306
4725	599	544	371	484	6825	211	215	252	299
4775	562	524	368	485	6875	202	210	247	292
4825	480	456	354	456	6925	201	204	244	291
4875	446	409	343	436	6975	201	200	240	287
4925	531	475	357	465	7025	199	193	238	284
4975	525	475	354	458	7075	195	190	237	281
5025	512	465	351	453	7125	188	186	230	273
5075	494	456	351	452	7175	185	184	228	267
5125	478	443	343	437	7225	179	181	229	265
5175	469	427	334	425	7275	177	178	222	266
5225	447	419	333	421	7325	176	171	215	259
5275	445	409	336	430	7375	176	164	212	244
5325	427	404	338	426	7425	174	164	205	241
5375	416	394	335	417	7475	167	161	201	243
5425	411	385	330	422	7525	161	158	201	235
5475	397	379	332	412					

6 SYNTHETIC $B-V$ INDICES

Table 5 contains photometric data and spectral types for common stars of our programme and the *WBVR* catalogue. This catalogue (Kornilov *et al.*, 1991) 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 made near Alma–Ata at a height of about 3000 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 0.001 mag of average magnitudes in the W, B, V and R bands, $C=2$ corresponds to 0.002 mag and so on).

Spectral types are taken from the *WBVR* catalogue. The last column of Table 5 contains synthetic $B-V$ colour indices calculated on the basis of energy distribution data from Table 3 and response curves for the B and V bands from the *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 the response curves of the W and R bands differ from zero.

The value $C=0.620$ of the integration constant was taken (Kharitonov *et al.*, 1994) for calculation of the $B-V$ colour indices. This value is the mean for four sets of bright stars with reliable energy distribution data. Observed $B-V$ colour indices for these stars were taken from *WBVR* catalogue.

The mean difference between the observed and synthetic $B-V$ indices for 16 stars common to the *WBVR* catalogue and our spectrophotometric programme is

Table 4. **Mean inner accuracy of energy distribution data**

λ(Å)	RMS(%)	λ(Å)	RMS(%)	λ(Å)	RMS(%)	λ(Å)	RMS(%)
3425	2.3	4475	1.1	5525	0.9	6575	1.2
3475	2.1	4525	1.0	5575	1.0	6625	1.0
3525	2.0	4575	0.9	5625	0.8	6675	1.0
3575	1.9	4625	0.8	5675	0.9	6725	1.1
3625	1.7	4675	0.9	5725	1.0	6775	1.1
3675	1.7	4725	0.9	5775	0.9	6825	1.2
3725	1.9	4775	1.0	5825	0.9	6875	1.2
3775	2.0	4825	1.1	5875	0.9	6925	1.2
3825	1.7	4875	1.0	5925	0.9	6975	1.2
3875	1.6	4925	0.9	5975	0.8	7025	1.3
3925	1.8	4975	0.9	6025	0.8	7075	1.2
3975	1.9	5025	0.9	6075	0.8	7125	1.4
4025	1.4	5075	0.9	6125	0.9	7175	1.5
4075	1.2	5125	0.9	6175	1.0	7225	1.6
4125	1.2	5175	0.9	6225	0.9	7275	1.5
4175	1.0	5225	0.9	6275	0.9	7325	1.6
4225	1.0	5275	0.9	6325	0.9	7375	1.7
4275	1.1	5325	0.9	6375	1.0	7425	1.8
4325	1.3	5375	0.9	6425	0.9	7475	1.7
4375	1.2	5425	0.8	6475	1.0	7525	2.0
4425	1.1	5475	0.9	6525	1.3		

0.016 mag. For eight stars this difference is less than or equal to 0.01 mag. For α Lyr$\langle B-V\rangle_{\rm obs} - \langle B-V\rangle_{\rm syn}$ is 0.023 mag, if the energy distribution according calibration by Hayes(1985) is taken. Energy distribution data of seven standard stars used in the observations of programme stars were obtained by means of comparison with α Lyr. So the energy distribution of all programme stars is based on the α Lyr calibration mentioned above. Therefore the difference between the observed and synthetic $B-V$ indices for programme stars is due mainly to the α Lyr calibration used.

7 CONCLUSION

Energy distribution data for the stars presented in Table 3 were obtained with a mean internal accuracy about 1–1.5% in the range 4000–6000Å. Only in the ultraviolet and near infrared edges of the spectrum did the error increase slightly but its mean value did not exceed 2%. 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 0.02 mag. 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 investigated stars as spectrophotometric standards.

Table 5. WBVR photometry and syntiletic $B - V$ colour index

HD	Sp	$\langle V \rangle$	$\langle W - B \rangle$	$\langle B - V \rangle$	C	$\langle B - V \rangle_{syn}$
7193	F5	6.896	-0.202	0.477	3	0.466
18881	A0	7.144	-0.106	-0.014	3	-0.042
36150	A2	6.495	0.087	0.248	6	0.225
59975	A3	7.287	0.176	0.109	4	0.101
68903	B8	7.283	-0.292	-0.086	8	-0.109
88046	F2	7.167	-0.084	0.404	6	0.380
145891	A3	7.026	0.093	0.250	2	0.241
146102	F5	6.930	-0.001	0.525	3	0.506
153376	F8V	6.918	-0.002	0.631	4	0.597
155193	F8IV	7.013	-0.106	0.547	4	0.539
168481	F0p	6.980	0.271	0.286	4	0.278
171888	F8	6.890	-0.092	0.567	2	0.544
183936	F2III	6.958	-0.129	0.454	4	0.448
196203	F8	7.093	-0.039	0.509	3	0.503
210733	F51V	7.119	-0.075	0.398	3	0.388
213575	G2V	6.951	0.004	0.677	3	0.667
α Lyr	A0	0.028	0.044	0.011	3	-0.012

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

Glushneva, I. N., Kharitonov, A. V., Kayazeva, 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.

Kharitonov, A. V., Tereshchenko, V. M., and Knyazeva, L. N. (1988) *Spectrofotometricheskij Katalog Zvezd*, Nauka, Alma-Ata.

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

Kornilov, V. G., Volkov, I. M., Zakharov, A. I. *et al.* (1991) *Trudy Gos. Astron. Inst. Shternberga* **63**, 399 pp.

Nesterov, V. V., Ovchinnikov, A. A., Cherepashchuk, A. M., 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. E., Glushneva, I. N., Doroshenko, V. T., Kolotilov, E. A., Mossakovskaya, L. V., Ovchinnikov, S. L., and Fetisova, T. S. (1982) In: 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*, University Press, Moscow, p. 156.