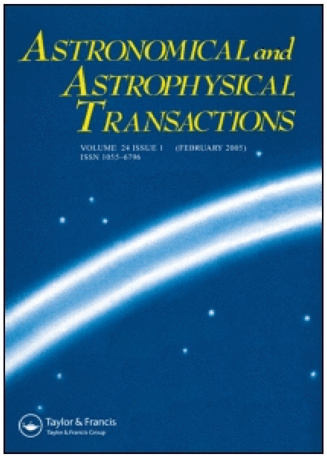

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

EFFECTIVE TEMPERATURES OF SOLAR TYPE STARS

I. N. Glushneva [a]; V. I. Shenavrin [a]; I. A. Roshchina [a]
[a] Sternberg Astronomical Institute, Universitetskij prosp. 13, 119 899, Moscow, Russia.

Online Publication Date: 01 January 2002
To cite this Article: Glushneva, I. N., Shenavrin, V. I. and Roshchina, I. A. (2002) 'EFFECTIVE TEMPERATURES OF SOLAR TYPE STARS', Astronomical & Astrophysical Transactions, 21:4, 317 - 325
To link to this article: DOI: 10.1080/10556790215603
URL: http://dx.doi.org/10.1080/10556790215603

Astronomical and Astrophysical Transactions, 2002, Vol. 21(4–6), pp. 317–325 Taylor & Francis
Taylor & Francis Group

EFFECTIVE TEMPERATURES OF SOLAR TYPE STARS

I. N. GLUSHNEVA*, V. I. SHENAVRIN and I. A. ROSHCHINA

Sternberg Astronomical Institute, Universitetskij prosp. 13, 119 899, Moscow, Russia

(Received 26 February 2002)

For 29 stars of G0–G5 spectral types with color indices $0.60 \leq B\text{–}V \leq 0.68$ and parallaxes obtained by Hipparcos satellite effective temperatures, angular diameters and radii are determined by means of the method of infrared fluxes (IRFM) on the basis of JHKLM photometry. Effective temperatures obtained by iterations in the process of combined determination of the $T_{\rm eff}$ and angular diameter of star (T_1) and using modification of IRFM, so-called observation R-factor, (T_2) are compared. The mean differences of these two effective temperatures don't exceed 1% for all the IR bands.

For the majority of investigated stars (23 from 29) bolometric magnitudes are less than for the Sun.

The analysis of five parameters of solar-type stars investigated in this paper, such a effective temperature, bolometric magnitude, radius, metallicity and infrared color indices, shows that 18 Sco seems to be the most accetable candidate for solar "twins".

Keywords: Stars; Solar analogs; Stars – fundamental parameters; IR photometry

1 INTRODUCTION

The Infrared Flux Method (hereafter IRFM; Backwell and Shallis, 1977) is a wide spread method, which requires, as a basis, atmosphere models in addition to observational information.

IRFM seems to be especially adequate to analyse the temperatures of F, G and K stars because a considerable part of the total flux forms in the infrared.

We used IRFM for determination of the effective temperatures and angular diameters of solar-type stars (Glushneva *et al.*, 2000a – Paper 1; Glushneva and Shenavrin, 2000b – Paper 2). In both cases effective temperatures were obtained together with the angular diameters by means of the iterations.

In this paper we present physical parameters of the atmospheres for a more wide sample of solar-type stars. We analyse the effective temperatures determined also by means of IRFM using the so named R-factor and compare results which we obtained earlier (Paper 1 and Paper 2) with our new results and data of other authors.

The star–solar "twin" must have the same physical parameters in the limits of the accuracy of observations as the Sun: effective temperature, mass, age, luminosity, gravity, chemical

* Corresponding author.

ISSN 1055-6796 print; ISSN 1476-3540 online
DOI: 10.1080/105567902900299

composition, atmospheric velocity fields, magnetic field, chromospheric activity. The successful search for solar twins may result in the process of detailed investigation of solar type stars named solar analogs which have similar photometric characteristics.

The Solar color index *B–V* varies in rather wide limits according to data of different authors: from 0.62 or even less values up to 0.68. Cayrel de Strobel (1996) produced the list of 109 stars with color indices from 0.59 up to 0.69.

2 JHKLM PHOTOMETRY OF SOLAR-TYPE STARS

Photometric observations of stars in the infrared range were produced at the 125 cm reflector of the Sternberg Institute Crimean Station by means of JHKLM photometer (Nadzhip *et al.*, 1986). Each star of the program was observed for 2–3 nights. Atmospheric extinction was not taken into account in this spectral range because the observations were planned specially to reduce difference of airmass to a minimum. As a rule this difference was of an order of some thousandths of airmass and rarely reached 0.05.

BS 334, BS 458, BS 622, BS 915, BS 1411, BS 3775, BS 4031, BS 4917, BS 4932, BS 5131, BS 5933, BS 6018, BS 6075, BS 7328, BS 7957 and BS 8499 were used as standard stars. These stars were chosen from the catalogue by Johnson *et al.* (1966). As H, M, and for many stars, L magnitudes are absent in this catalogue, missing magnitudes were calculated using formulae presented in the paper by Koornneef (1983).

Accuracy of observations was $0.^{m}02$ in J, H and K bands, $0.^{m}03$ in L band and $0.^{m}05$ in M band.

IR magnitudes were transformed to monochromatic fluxes F_ν by means of calibration by Koornneef (1983).

Monochromatic fluxes f_ν coming from the surface of the star were obtained using Kurucz models (1993).

Table I contains the list of investigated stars with HD and BS catalogues numbers, spectra, *V* magnitudes, color index, *B–V*, effective temperature, obtained from spectroscopic observations, bolometric magnitude, *lgg*, total flux and parallax obtained by Hipparcos satellite.

$M_{\rm bol}$ marked by the asterisks were determined from ground based observations.

HD 213575 was included in the list because the energy distribution of this star is very similar to the Sun (Glushneva *et al.*, 2000a).

Angular diameter and effective temperature were found by means of the method of infrared (IR) fluxes on the basis of JHKLM photometry.

3 EFFECTIVE TEMPERATURE OF STARS

The method of IR fluxes (Blackwell and Shallis, 1977) consists of combined determination of the effective temperatures and angular diameters of stars using total flux and monochromatic flux in the IR range.

The accuracy is 1% in temperature and 2% in angular diameter if initial data are precise enough.

TABLE I Photometric and Spectroscopic Parameters of Investigated Stars.

HD	*BS*	*Sp*	*V*	*B-V*	T_{eff}	M_{bol}	*lg–g*	$F \times 10^7 erg/cm^2 s$	π
1835	88	G2V	6.402	0.660	5781	4.775	4.50	0.717	0.049
10307	483	G1.5V	4.965	0.623	5538	4.394	4.40	2.61	0.079
11131		dG1	6.752	0.625	5820	4.71*	4.37	0.596	0.043
13974	660	G0V	4.873	0.612	5623	4.612	4.50	2.91	0.092
19373	937	G0V	4.060	0.599	5970	3.887	4.06	6.05	0.095
20630	996	G5V	4.843	0.674	5631	4.916	4.83	3.12	0.109
25680	1262	G5V	5.910	0.626	5794	4.63*	4.30	1.21	0.063
27685		G4V	7.850	0.679	5623	4.917	4.50	0.191	0.027
28099		G2V	8.105	0.662	5775	4.695	4.50	0.164	0.021
28344		G1.5V	7.836	0.605	5902	4.396	4.50	0.184	0.021
28992		G5V	7.905	0.685	5848	4.674	4.50	0.173	0.023
34411	1729	G1IV-V	4.705	0.622	5888	4.136	4.17	3.33	0.079
72905	3391	G1V	5.648	0.621	5848	4.801	4.40	1.40	0.070
76151	3538	G3V	6.013	0.671	5727	4.773	4.50	1.01	0.058
86728	3951	G1.5V	5.385	0.676	5727	4.423	4.28	1.85	0.067
89010	4030	G1.5IV-V	5.968	0.668	5598	3.457	4.00	1.09	0.033
109358	4785	G0V	4.250	0.598	5943	4.586	4.45	4.99	0.119
115043		G1V	6.815	0.615	5861	4.712	4.50	0.478	0.039
117176	5072	G5V	4.973	0.727	5483	3.570	3.75	2.72	0.055
141004	5868	G0V	4.419	0.611	5984	4.026	4.11	4.26	0.085
142267	5911	G1V	6.096	0.609	5794	4.796		0.946	0.057
143761	5968	G2V	5.411	0.615	5768	4.117	3.98	1.76	0.057
146233	6060	G2Va	5.499	0.650	5789	4.693	4.18	1.61	0.071
186408	7503	G1.5V	5.986	0.659	5780	4.234	4.29	1.03	0.046
186427	7504	G2.5V	6.244	0.671	5765	4.518	4.30	0.823	0.047
187923	7569	G0V	6.164	0.664	5727	3.872		0.885	0.036
193664	7783	G3V	5.932	0.601	5998	4.640		1.10	0.057
213575		G2V	6.951	0.677	–	3.983		0.482	0.028
217014	8729	G2.5IVa	5.459	0.676	5755	4.458	4.18	1.68	0.065

TABLE II Effective Temperatures of Stars.

HD	T_{J1}	T_{J2}	T_{H1}	T_{H2}	T_{K1}	T_{K2}	T_{L1}	T_{L2}	T_{M1}	T_{M2}	T_{mean}
1835	5723	5728	5630	5592	5624	5569	5698	5682	5624	5554	5642
10307	5707	5760	5756	5718	5785	5767	5678	5616	5685	5650	5712
11131	5821	5930	5770	5785	5763	5779	5777	5798			5803
13974	5641	5519	5540	5474	5552	5461	5520	5441	5563	5456	5517
19373	5963	5938	5966	5979	5968	5964	5968	5966	5973	5963	5965
20630	5612	5739	5685	5743	5650	5702	5612	5644	5592	5635	5661
25680	5802	5880	5807	5838	5788	5814	5788	5816	5777	5807	5812
27685	5588	5411	5554	5488	5543	5447	5531	5445			5501
28099	5747	5770	5761	5769	5747	5729	5734	5722			5747
28344	5833	5640	5767	5680	5780	5789	5820	5742			5756
28992	5825	5618	5770	5687	5744	5649	5784	5702			5722
34411	5938	5878	5885	5840	5892	5846	5918	5836	5850	5768	5865
72905	5815	5618	5791	5711	5820	5755	5791	5702			5750
76151	5642	5519	5626	5592	5631	5583	5522	5472			5574
86728	5657	5574	5622	5582	5622	5569	5645	5610	5596	5518	5600
89010	5513	5551	5579	5614	5594	5632	5598	5646	5565	5626	5592
109358	5771	5519	5771	5690	5696	5702	5721	5628	5674	5505	5668
115043	5731	5706	5773	5789	5755	5755	5622	5578			5714
117176	5398	5265	5358	5303	5355	5303	5350	5298	5350	5253	5323
141004	5867	5715	5841	5785	5859	5798	5815	5761	5892	5824	5816
142267	5701	5649	5678	5652	5664	5618	5611	5574			5643
143761	5762	5671	5652	5635	5652	5645	5490	5390	5583	5480	5526
146233	5697	5649	5643	5603	5668	5645	5723	5722	5766	5789	5691
186408	5722	5706	5695	5687	5659	5623	5573	5522	5680	5650	5652
186427	5710	5629	5657	5606	5646	5569	5562	5474	5675	5599	5613
187923	5664	5574	5609	5561	5609	5543	5582	5524			5583
193664	6017	6046	5916	5890	5894	5862	5828	5779	6023	6036	5929
213575	5751	5770	5673	5655	5688	5663	5673	5646			5690
217014	5745	5758	5724	5725	5703	5698	5691	5670	5841	5914	5717

The basic formulae are:

$$T_{\mathrm{eff}}^4 = \frac{4F}{\sigma\theta^2}, \quad \theta = 2\sqrt{\frac{F_\nu}{f_\nu}}, \tag{1}$$

where

T_{eff} – effective temperature of the star
θ – angular diameter
F – total flux
F_ν – monochromatic flux, measured on the Earth
f_ν – monochromatic flux coming from the surface of the star.

Total flux was calculated using spectroscopic effective temperature and bolometric magnitude taken from Cayrel de Strobel and Friel (1998).

The modification of IRFM (Blackwell *et al.*, 1990) uses the ratio of the bolometric flux (F_{bol}) and the monochromatic flux at a chosen infrared wavelength of the continuum $F(\lambda_{\mathrm{IR}})$, both measured at the surface of the earth, as an indicator of T_{eff}.

This ratio is called the observational R-factor (R_{obs}).

The theoretical counterpart derived from models is obtained as the ratio between the integrated flux ($\sigma T_{\mathrm{eff}}^4$) and monochromatic flux at λ_{IR} at the surface of the star, taken from the model.

$$R_{\mathrm{obs}} = \frac{F_{\mathrm{bol}}}{F(\lambda_{\mathrm{IR}})} = \frac{\sigma T^4}{F_{\mathrm{mod}}(\lambda_{\mathrm{IR}}, T_{\mathrm{eff}}, [\mathrm{Fe/H}], g)}, \tag{2}$$

where the dependence on λ_{IR}, metallicity and surface gravity is taken into account.

In principle the dependence on models is not a critical point to the IRFM for spectral types earlier than late K where the IR opacity due to molecular bands is of minor importance. Another strong feature of the IRFM is the large sensitivity of R-factor to the effective temperature ($R \sim T_{\mathrm{eff}}^3$) and its slight dependence on another atmospheric parameters. So, the uncertainties of the obtained effective temperatures due to errors in the gravity and metallicity are small compared to those arising in the determination of the bolometric and monochromatic fluxes.

Table II presents the values of the effective temperatures of stars obtained at JHKLM bands by the method of iterations (T_1) and the modification of IRFM using $R_{\mathrm{obs}}(T_2)$.

As a rule T_1 is slightly more than T_2, but their mean ratio T_1/T_2 varies from 1.01 for J to 1.007 for L and M bands.

So the last column of Table II includes the mean values of T_{eff} between T_1 and T_2.

4 PARALLAXES, ANGULAR DIAMETERS AND RADII OF STARS

In the Table III high accuracy parallaxes obtained by the Hipparcos satellite, together with data on parallaxes from the fourth edition of the Bright Star Catalogue (BS-4) and Yale catalogue are presented.

In some cases the parallaxes from these sources differ from one to another considerably, especially for BS 3538, BS 5911, BS 5968 and BS 7569. The parallax of BS 7569, obtained by Hipparcos, is 60% larger than taken from BS-4, for other three stars the differences are about 40%. For three stars from four parallexes of Hipparcos, are more than from BS-4.

TABLE III Parallaxes of Stars.

	HD	*BS*	$\Pi_{(BS\text{-}4)}$	*Yale*	*Hipparcos*
1	1835	88	49	41.9	49.05
2	10307	483	81	74.2	79.09
3	11131	–	–	–	43.47
4	13974	660	93	96.5	92.20
5	19373	937	92	91.9	94.93
6	20630	996	108	108.2	109.18
7	25680	1262	63	59.7	59.79
8	27685	–	–	–	26.96
9	28099	–	–	32.1	21.42
10	28344	–	–	–	21.09
11	28992	–	–	–	23.19
12	34411	1729	70	73.6	79.08
13	72905	3391	73	69.2	70.07
14	76151	3538	85	57.4	58.50
15	86728	3951	52	65.2	67.14
16	89010	4030	34	34.8	32.94
17	109358	4785	117	116.9	119.46
18	115043	–	–	39.2	38.92
19	117176	5072	43	53.9	55.22
20	141004	5868	94	84.9	85.08
21	142267	5911	41	42.3	57.27
22	143761	5968	40	39.6	57.38
23	146233	6060	62	62.9	71.30
24	186408	7503	39	46.6	46.25
25	186427	7504	39	–	46.70
26	187923	7569	22	23.3	36.15
27	193664	7783	67	68.2	56.92
28	213575	–	–	–	27.92
29	217014	8729	74	57.5	65.10

Table IV presents the mean values of angular diameter corresponding to the mean values of effective temperatures from Table II and total flux from Table I.

Table IV includes also radii of stars $R/R_\odot$, calculated on the basis of angular diameters and parallaxes obtained by Hipparcos.

We began the investigation of solar type stars (Glushneva *et al.*, 1986) from the determination of physical parameters of the atmospheres of 12 G0–G8 stars from the spectrophotometric catalogue of the Sternberg Astronomical Institute (Voloshina *et al.*, 1982).

The comparison with the values of $R/R_\odot$ from the paper by Glushneva *et al.* (1986), where parallexes from BS-4 were used shows that for common stars in some cases $R/R_\odot$ obtained in this paper are more than $R/R_\odot$ from Glushneva *et al.* (1986). (3 stars from 9 common stars), for 5 stars $R/R_\odot$ values are less.

5 CONCLUSION

There are 10 common stars in our Paper and the publication by Alonso *et al.* (1996) where effective temperatures are determined for an extended sample of dwarfs and subdwarfs.

For 5 stars we could compare $T_{\rm eff}$ obtained at the bands J, H, K and for the other 5 stars only at the J and K bands (in the Paper by Alonso *et al.* the data for *H* are absent). As a rule $T_{\rm eff}$ by Alonso *et al.* are more 1–2%, but the main reason of this discrepancy is in the values of total flux, which is 2–9% more than $F_{\rm tot}$ from our Table I. They obtained total flux from the calibration as a function of K, (*V*-K) and [Fe/H]. We calculated $F_{\rm tot}$ using spectroscopic

TABLE IV Angular Diameters (in milliarcsec) and Radii of Stars.

	HD	*BS*	Θ_{mean}	$R/R_{\odot}$	$R/R_{\odot GMK}$
1	1835	88	0.460	1.01	
2	10307	483	0.856	1.17	1.04
3	11131		0.396	0.99	
4	13974	660	0.969	1.14	
5	19373	937	1.192	1.36	1.36
6	20630	996	0.953	0.94	1.04
7	25680	1262	0.563	0.97	
8	27685		0.249	1.00	
9	28099		0.212	1.09	
10	28344		0.224	1.15	
11	28992		0.220	1.03	
12	34411	1729	0.917	1.25	1.32
13	72905	3391	0.619	0.96	
14	76151	3538	0.559	1.04	
15	86728	3951	0.750	1.21	
16	89010	4030	0.578	1.89	
17	109358	4785	1.202	1.09	1.03
18	115043		0.366	1.01	
19	117176	5072	1.006	1.98	2.08
20	141004	5868	1.055	1.34	1.16
21	142267	5911	0.528	1.00	
22	143761	5968	0.732	1.39	
23	146233	6060	0.677	1.03	
24	186408	7503	0.549	1.29	1.42
25	186427	7504	0.498	1.14	1.36
26	187923	7569	0.522	1.57	
27	193664	7783	0.516	0.98	
28	213575		0.371	1.43	
29	217014	8729	0.679	1.13	

Note: GMK – Glushneva, Makarova, Kharitonov (1986).

temperatures and bolometric magnitudes from the Paper by Cayrel de Strobel and Friel (1998), where T_{sp} are determined with the accuracy 0.5% and $M_{bol} - 0.1$.

The same situation may be seen in the comparison of F_{tot} and T_{eff} for our data and results obtained by Blackwell and Lynas-Gray (1994): the difference in total flux is from 3 to 8% (four common stars) and 1–2% in T_{eff} (our F_{tot} and T_{eff} are less).

Bell and Gustafsson (1989) used K-band and their own theoretical model atmospheres for determination of T_{eff}. Their values of effective temperature obtained using *R*-factor are systematically higher than in the paper by Blackwell *et al.* (1977). The mean difference of T_{eff} for these stars common with our programme is 2% for K-band where effective temperatures obtained by Bell and Gustafsson are higher. It may be connected with the differences in the total flux, because their data of F_{tot} are 10% more then our ones presented in the Table I.

Minimal discrepances in the values of T_{eff} appear in the comparison of six stars common with Arribas and Martinez-Roger (1989): systematic differences are absent and the mean discrepancy is less than 1%.

For the majority of investigated stars (23 from 29) bolometric magnitudes are less than for the Sun.

Taking into account that the mean error bar adopted for the stars with Hipparcos parallexes is 0.1 for M_{bol} and $M_{bol\odot} = 4.75$, in the limits 4.65–4.85 are M_{bol} only for 9 stars. Bolometric magnitude of 16 Cyg A, 16 Cyg B and 51 Peg are outside these limits. M_{bol} of 18 Sco is inside this interval.

For T_{eff} the mean error bar is 1% (60 K). Taking into account that the spectrosopic effective temperature of the Sun is 5770 K, the limits for T_{eff} are 5710–5830 K.

Analysing the intervals in M_{bol} are T_{eff} jointly we see that only HD 1835, HD 11131, HD 28099, HD 76151, HD 115043 and HD 146233 (18 Sco) get into the box $M_{\mathrm{bol}\odot} \pm 0.1$ and $T_{\mathrm{eff}} = T_{\mathrm{eff}\odot} \pm 60\,\mathrm{K}$.

We are to add the condition for chemical composition $[\mathrm{Fe/H}] = 0.00 \pm 0.10$ (Cayrel de Strobel and Friel, 1998) HD 1835, HD 28099 must be excluded and HD 11131 and HD 115043 has [Fe/H] very near the boundary of accuracy interval.

	[Fe/H]	$R/R_\odot$	$M_{bol\ IRF}$	$M_{bol\ sp}$
HD 1835	+0.18	1.00	4.765	4.775
HD 11131	−0.09	1.00	4.678	4.710
HD 28099	+0.16	1.06	4.579	4.695
HD 76151	+0.07	1.02	4.752	4.773
HD 115043	−0.08	1.01	4.709	4.712
HD 146233	0.00	1.02	4.699	4.693

HD 11131, HD 76151, HD 115043 and HD 146233 (18 Sco) get into the limits of mean bars for T_{eff}, M_{bol}, R and [Fe/H].

It is interesting to compare infrared (IR) color indices of these four stars with corresponding indices of the Sun.

	V	*V-J*	*V-H*	*V-K*	*V-L*	*V-M*
HD 11131	6.752	1.19	1.53	1.60	1.61	–
HD 76151	6.013	1.16	1.47	1.54	1.64	–
HD 115043	6.815	1.09	1.36	1.44	1.56	–
HD 146233	5.50	1.11	1.45	1.50	1.48	1.51
Sun	–	1.03–1.116	1.35–1.47	1.41–1.50	1.445–1.53	1.39–1.51

IR indices of HD 11131 are more than solar indices, *V*-L of HD 115043 is more than upper limit of solar *V*-L index.

For the Sun the intervals of color indices according to the data by different authors are presented (Glushneva *et al.*, 2000a).

We can see that *V*-J, *V*-K and *V*-L for HD 75161 are more than for the Sun, especially *V*-L, which is 0.11 mag more than the larger value of solar *V*-L on the boundary of the interval. As was mentioned above the accuracy of L magnitude is not worse than 0.03 mag, J and K − 0.02 mag.

Effective temperature T_{L} for this star is 100 K less than T_{J}, T_{H} and T_{K} (Tab. II).

IR indices of HD 11131 are more than solar indices, *V*-L of HD 115043 is more than upper limit of solar *V*-L index.

All IR color indices of 18 Sco get to the interval of solar ones obtained by different authors.

If we take into account five parameters of solar analogs investigated in this paper, such as effective temperature, bolometric magnitude, radius, chemical composition and infrared color indices 18 Sco seems to be the most acceptable candidate for solar “twins”.

References

Alonso, A., Arribas, S. and Martinez-Roger, C. (1996). *Astron. Astrophys. Suppl. Ser.*, **117**, 227.
Arribas, S. and Martinez-Roger, C. (1989). *Astron. Astrophys.*, **215**, 305.
Bell, R. A. and Gustafsson, B. (1989). *Mon. Not. R. Astron. Soc.*, **236**, 653.

Blackwell, D. E., Petford, A. D., Arribas, S., Haddock, D. J. and Selby, M. J. (1990). *Astron. Astrophys.*, **232**, 396.
Blackwell, D. E. and Lynas-Gray, A. E. (1994). *Astron. Astrophys.*, **282**, 899.
Blackwell, D. E. and Shallis, M. J. (1977). *Mon. Not. R. Astron. Soc.*, **180**, 177.
Cayrel de Strobel, G. (1996). *Astron. Astrophys. Rev.*, **7**, 243.
Cayrel de Strobel, G. and Friel, E. D. (1998). In: Hall, J. C. (Ed.), *Solar Analogs: Proccedings of the Second Lowell Fall Workshop*, p. 93.
Glushneva, I. N., Makarova, E. A. and Kharitonov, A. V. (1986). In: Swings, J.-P., (Ed.), *Highlights of Asronomy*, **7**, p. 853.
Glushneva, I. N., Shenavrin, V. I. and Roshchina, I. A. (2000a). *Astron Zh.*, **7**(N4), 285.
Glushneva, I. N. and Shenavrin, V. I. (2000b). JENAM 2000. Spectrophotometric and photometric catalogues. Standard stars and solar analogs. *Proceedings of the connected symposium*, St. Petersburg, Russia, June 5–7, 2000, p. 105.
Hipparcos and Tycho Catalogues. 1997. ESA SP-1200.
Hoffleit, D. and Jasckek, C. (1982). *Yale Catalogue of Bright Stars*, 4th ed., Yale University.
Johnson, H. L., Mitchell, R. I., Iriarte, B. and Wis'niewski, W. Z. (1966). *Comm. Lunar and Planet Lab.*, **63**, 99.
Koornneef, J. (1983). *Astron. Astrophys. Suppl. Ser.*, **51**, 489.
Kurucz, R. L. (1993). CD-ROM N13.
Nadzhip, A. E., Shenavrin, V. I. and Tikhonov, V. G. (1986). In: Shtenberga, P. K. (Ed.), *Trudy Gos. Astron. Inst.*, Vol. 58, p. 119.
Voloshina, I. B., Glushneva, I. N., Doroshenko, V. T., Kolotilov, E. A., Mossakovskaya, L. V., Ovchinnikov, S. L. and Fetisova ,T. S. (1982). In: Glushneva, I. N. (Ed.), *Spectrophotometry of Bright Stars.* Moscow, Nauka.