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SPECTROPHOTOMETRIC STANDARDS 8^m-10^m. Ш. THE EQUATORIAL ZONA FROM 12^h TO 24^h

Abstract. This article is the third paper from cycle of notices, which devoted of the creation of spectrophotometric standards of in-termediate brightness. In paper the absolute energy distribution in visual region of spectra for 12 B-A-stars 8^m-10^m were present. The investigated stars-standards are located along the celestial equator (δ = ±3˚) in the range of right ascensions from 0^h to 12^h. Together with the stars from the second work of this cycle, they form a system of equatorial standards of intermediate brilliance. As a product of these two works, the total number of spectrophotometric standards of 8m-10m in the visible spectrum area has more than doubled.

Equipment, observation methods, reductions and computations detailed described in our first and second papers. The distribution of energy was studied in the range of 340nm - 665nm, the spectral resolution of the data is 5nm, the relative standard error of the received data - from 2 to 6%. The reliability of the results is assessed by comparing the calculated and directly observed star magnitudes of the investigated stars in the UBV-system. For several stars, the distribution of energy in their spectrums, in addition to the observations, was calculated by photometric data. Differences between them in the ultraviolet region can reach 20-30% due to differences in the course of energy distribution curves in their spectrums, errors in spectral classification and determination of interstellar absorption.

Keywords: stars, energy distribution, spectrophotometric standards, comparison with photometry.

Introduction. This work is a continuation of the work on the creation of spectrophotometric standards of intermediate brightness [1,2]. Once again, the creation of spectrophotometric standards remains an urgent task. There should be as many standards as possible, as the number of observations and the accuracy of the data obtained depend on them. This paper presents the distribution of energy in the visible spectrum area for 12 stars of the early spectral classes of 8^m - 10^m. As in the work [2], the stars studied are located along the equator (±3 degrees), but cover the zone from 12^h to 24^h. Together with the stars from the second work of this cycle, they form a system of equatorial standards of intermediate brightness. Thanks to these two works, the total number of stars - spectrophotometric standards of 8^m-10^m in the visible area of the spectrum has more than doubled.

Observations, reductions and results. The list and main characteristics of the stars studied are given in table 1. The second column contains numbers on HD catalogs, if they are not in it - on the BD catalog. In general, the stars studied are slightly dimmer than the stars from the previous work [2]. The five stars recommended in the standards are weaker than 10^m. The stars observed have not been specifically investigated for the change, but they do not appear as variables in the SIMBAD database. It should be noted that, unfortunately, even in modern photometric catalogs, the differences between magnitudes V and color-indexes B-V are relatively often 0.05^m or more. The accuracy of spectral classification in most cases is one or two subclasses.

The observations are made on the 70-centimetre reflector AZT-8 (D : F = 1 : 16) and on the 60-cm "Zeiss-600" (D : F = 1 : 12) with the help of spectrograph, which is specifically designed for absolute measurements (SAM) [3] . The dispersing element of the spectrograph is the toroidal diffraction grate and the detector is the CCD camera ATIC-490EX.

Table1 - List of investigated stars and their main characteristics

№	HD or BD	α_{2000}	δ_{2000}	V	B - V	Sp
1	BD+01 2668	$12^h 13^m 25.3^s$	01° 09' 22"	10.29^m	-0.09^m	B5*
2	BD+02 2711	13 42 19.0	01 30 18	10.26	-0.11	B5
3	BD+02 2790	14 14 25.9	01 47 58	10.11	0.03	A0
4	HD136161	15 19 14.7	-02 10 02	8.86	0.28	A3V(A2V)
5	HD151355	16 46 47.0	02 12 34	8.85	-0.09	B4/5V
6	HD162628	17 51 52.6	02 53 59	8.28	0.16	B9.5V
7	HD174648	18 51 41.0	-01 45 35	8.81	0.09	B9.5V
8	HD185296	19 38 21.0	01 30 14	9.68	0.23	B9II
9	BD -03 4950	20 34 43.6	-02 41 44	10.00	0.09	A0 (B8)
10	BD+01 4436	21 10 11.5	02 14 20	9.99	0.03	A0
11	HD215112	22 42 58.0	-02 40 57	8.25	-0.03	B9IV-V
12	BD+02 4661	23 23 38.20	02 55 57	10.05	0.38	F2

*- the spectral class was "assigned" according to the color-index B-V.

The five stars from the catalogue [3] were used as primary standards, and information about them is given in our work [1]. The observations were carried out by a method of equal heights, which allowed the average value of the atmosphere's transparency factor for observation seating to be used in reductions. Each star was observed 3 to 8 times. Due to the unstable transparency of the atmosphere, more than a third of the data obtained from the observations were released. Note that the astronomical climate on the observatory "Kamenskoye Plateau" is deteriorate every year. The deterioration of transparency and the increase in the brightness of the sky are due to the rapid growth of the metropolis (Almaty), and the decrease in the number of clear time - global climate change. Apparently, it is no longer rational to observe the fundamental photometry and absolute spectrophotometry here.

The resulting CCS spectrograms are processed in the MaxIm DL-6 package. The process of processing personnel and necessary reductions is detailed in our works. Let's focus only on measurements of star spectrums - primary standards.

For secondary standards we took the values of luminosities and counts for the quasi-continuous spectrum. The lighting values for them in the hydrogen lines area were obtained earlier by graphic interpolation of energy distribution curves. Line counts for each register were also interpolated. This procedure can be done by numerical method using a computer, however, we used a "manual" method. Calibrated and with a subtracted register background, we printed out and made the transcripts interpolate in the hydrogen lines. The countdowns were re-entered into the computer. The hydrogen line H_β was a rapper at the breakdown of the spectrum by 50-angstrom intervals. The resulting non-atmospheric values of monochromatic light for twelve stars, recommended as spectrophotometric standards of intermediate brightness are presented in table 2.

Table 2 - The energy distribution for investigated stars in the absolute units [10^{-7} watt $m^{-2}m^{-1}$]

HD or BD	BD+01 2668	BD+02 2711	BD+02 2790	HD 136161	HD 151355	HD 162628	HD 174648	HD 185296
λ, A	1	2	3	4	5	6	7	8
3425	42.0	59.2	30.8	57	251	183	87	34.4
3475	41.2	64.1	30.9	54	241	162	95	30.7
3525	39.2	63.3	27.9	69	232	164	91	29.7
3575	42.1	61.5	31.9	61	231	166	89	31.2
3625	40.0	60.8	29.3	60	230	165	90	33.1
3675	41.8	55.1	36.9	60	220	166	91	35.6
3725	43.0	56.8	41.1	63	219	184	103	42.0
3775	51.1	55.0	47.4	75	224	215	121	49.1
3825	58.4	64.3	56.0	96	245	265	153	61.4
3875	67.7	73.5	64.2	110	270	314	177	70.7
3925	68.2	74.3	70.0	122	280	348	194	76.3
3975	73.3	79.4	71.7	143	299	396	212	84.0

Continuation of the table 2

1	2	3	4	5	6	7	8	9
4025	72.3	79.2	70.9	160	291	417	225	85.1
4075	67.4	72.0	64.0	144	268	372	205	80.5
4125	64.0	69.7	64.2	147	258	364	200	77.2
4175	65.7	68.3	66.9	158	257	389	209	79.7
4225	64.4	66.3	63.4	153	245	375	201	77.3
4275	60.0	60.8	57.6	145	231	354	188	74.4
4325	55.2	56.0	51.8	126	205	296	165	67.9
4375	55.5	55.3	55.0	135	204	309	167	68.1
4425	55.4	53.9	56.4	143	203	328	175	70.0
4475	54.1	52.8	55.8	142	195	322	173	68.6
4525	51.5	51.9	54.7	140	193	320	170	68.3
4575	49.6	50.5	53.3	138	186	315	167	66.7
4625	47.9	48.0	51.7	137	181	309	164	66.0
4675	46.4	47.1	50.1	136	175	305	160	64.0
4725	43.6	45.2	47.6	131	166	291	154	61.8
4775	41.0	41.9	43.8	126	156	273	144	60.3
4825	37.9	38.7	39.3	113	143	241	129	55.8
4875	36.6	37.7	38.2	106	138	225	122	53.7
4925	39.0	38.0	41.8	117	140	250	133	57.2
4975	37.6	37.3	42.0	120	141	257	137	58.5
5025	36.4	35.5	41.6	119	138	257	135	57.7
5075	36.2	35.4	40.8	120	135	254	133	57.8
5125	35.8	34.2	39.4	117	131	248	129	56.4
5175	34.9	33.7	38.3	113	127	241	126	54.7
5225	33.7	32.3	37.1	114	123	236	123	54.1
5275	31.7	31.8	36.2	112	118	230	118	53.2
5325	30.9	30.3	35.2	108	114	224	115	52.6
5375	30.4	29.5	35.0	108	109	220	113	52.5
5425	30.8	28.8	34.6	108	107	217	110	52.5
5475	28.8	27.6	33.1	107	105	213	109	51.6
5525	27.9	26.4	32.7	105	102	210	107	51.3
5575	27.6	26.2	31.8	101	101	210	106	51.0
5625	27.3	25.5	30.7	100	97	205	103	50.0
5675	25.5	25.1	30.4	100	94	200	100	49.4
5725	25.6	23.6	29.8	99	92	198	99	48.7
5775	24.4	23.2	29.1	97	89	191	96	47.3
5825	23.6	22.4	28.2	96	86	188	94	47.3
5875	22.7	22.2	27.4	94	82	183	92	46.0
5925	21.9	21.5	27.2	93	82	183	90	45.3
5975	21.5	20.8	27.5	92	81	180	88	44.7
6025	21.3	20.7	25.9	90	79	178	88	43.8
6075	20.6	20.1	25.3	89	76	173	86	42.9
6125	19.0	19.6	25.4	88	74	169	82	42.5
6175	19.2	19.1	24.5	86	72	164	80	40.7
6225	17.8	18.6	24.2	85	70	162	80	39.5
6275	18.3	18.1	22.8	81	68	156	78	39.4
6325	17.6	*17.6	*22.4	*79	*67	*152	*77	38.2
6375	16.6	*17.2	*21.9	*78	*65	*148	*77	37.5
6425	16.0	*16.8	*21.5	*76	*63	*144	*71	36.4
6475	15.8	*16.5	*21.0	*74	*62	*141	*69	35.2
6525	14.7	*15.6	*19.6	*70	*59	*131	*63	33.4
6575	14.0	*14.7	*17.3	*62	*55	*115	*61	33.0
6625	16.0	*15.3	*19.6	*69	*58	*131	*67	35.1
6675	16.5	*15.0	*19.4	*69	*56	*129	*65	33.5

Table 2, continued

λ, A	BD-03 4950	BD+01 4436	HD 215112	BD+02 4661	λ, A	BD-03 4950	BD+01 4436	HD 215112	BD+02 4661
	9	10	11	12		9	10	11	12
3425	28.3	23.1	236	30.0	5075	44.5	45.5	239	47.9
3475	25.7	28.7	214	27.0	5125	42.4	44.1	231	46.5
3525	28.1	22.8	238	36.0	5175	41.4	42.8	224	45.3
3575	28.5	25.0	209	30.8	5225	40.4	41.5	220	44.9
3625	28.5	24.7	206	29.4	5275	39.2	39.9	213	45.1
3675	28.6	27.8	210	31.5	5325	38.5	39.2	204	44.5
3725	30.8	31.3	221	31.4	5375	38.2	38.2	202	43.9
3775	33.2	36.1	245	32.2	5425	38.1	37.5	199	43.7
3825	45.5	50.0	298	37.4	5475	37.3	36.8	192	44.1
3875	51.7	63.0	366	44.3	5525	36.7	35.6	188	43.6
3925	58.3	68.6	387	44.2	5575	35.7	34.3	182	42.4
3975	64.4	78.4	419	51.4	5625	34.4	33.6	182	42.9
4025	67.5	79.4	448	58.3	5675	34.8	33.3	178	42.7
4075	64.9	73.3	420	57.2	5725	33.8	31.8	172	42.1
4125	66.4	75.9	399	55.2	5775	33.0	31.4	166	41.9
4175	68.3	76.8	411	56.6	5825	32.5	30.9	164	40.7
4225	64.5	76.3	399	55.5	5875	30.5	30.3	161	40.7
4275	58.8	70.3	375	54.2	5925	28.1	29.3	157	39.9
4325	56.1	60.8	332	51.6	5975	27.6	28.3	153	39.6
4375	58.3	61.7	331	52.1	6025	28.1	27.8	146	39.1
4425	59.8	65.7	345	53.6	6075	28.5	27.6	142	37.1
4475	58.4	64.8	335	53.8	6125	28.9	26.4	146	37.2
4525	57.8	62.4	326	53.8	6175	27.8	25.3	138	36.7
4575	56.6	60.5	313	53.8	6225	27.2	24.3	134	35.7
4625	54.5	59.5	308	53.4	6275	26.8	24.3	131	35.5
4675	53.0	58.0	298	52.7	6325	25.9	22.9	126	35.1
4725	50.6	54.6	287	51.0	6375	24.7	22.5	125	34.8
4775	47.2	52.0	271	49.8	6425	23.2	21.1	121	33.0
4825	42.7	45.7	247	46.8	6475	22.5	21.2	118	32.4
4875	43.4	42.1	229	45.2	6525	21.0	19.0	109	30.8
4925	45.7	45.8	248	47.9	6575	20.1	17.6	103	30.3
4975	46.0	47.0	249	47.5	6625	21.4	19.2	103	31.7
5025	45.0	46.1	244	47.9	6675	22.8	18.8	104	31.4

For six stars spectral observations was execute in region from 3400A to 6300A. For them, the energy distribution curves in the area of 6300A-6650A were extrapolated. In Table 2, these values are marked with an asterisk. Extrapolation is done for several reasons. First, extrapolated data can be used for standardization. Second, they allow comparisons of V and B-V energy calculated from energy distribution with directly observed photometric data. Extrapolation in this area is quite confident, as the course of curves of normal energy distribution here for stars of close spectral classes and interstellar absorption varies slightly. At extrapolation was use normal energy distributions obtained in the works [5, 6]. And, finally, in order to represent data of table 2 in identical form for all stars.

Comparison with photometrical data. Spectral energy distribution for the studied stars was obtained for the first time. Roughly assess the reliability of the received data can be indirectly - by comparing the observed stellar magnitudes with the magnitudes calculated from energy distributions. The resulting discrepancies will to some extent characterize the reliability of our results. This method has been used by us quite often and are detail described, in particular, in the work [2]. Therefore here we let us remind only that the calculations used the reaction curves of the photometric bands received by V.Straizys [7] and the necessary constants were defined on the star Vega. Differences between the calculated from the spectral energy distribution and the directly observed V magnitudes V and color- indexes B-V are represented in Table 3 and on figures 1,2. Only two stars have big discrepancies in the band V : HD162628 и BD+02 4661. The reason of these discrepancies we not know.

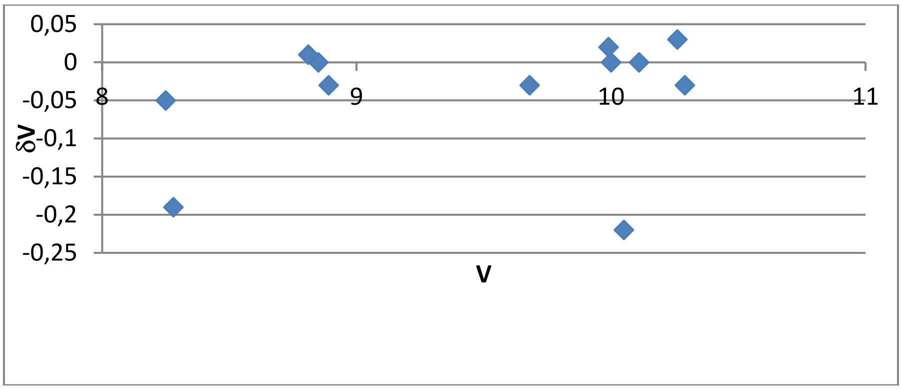

Figure 1 - Dependence of discrepancies δV from stellar magnitude V

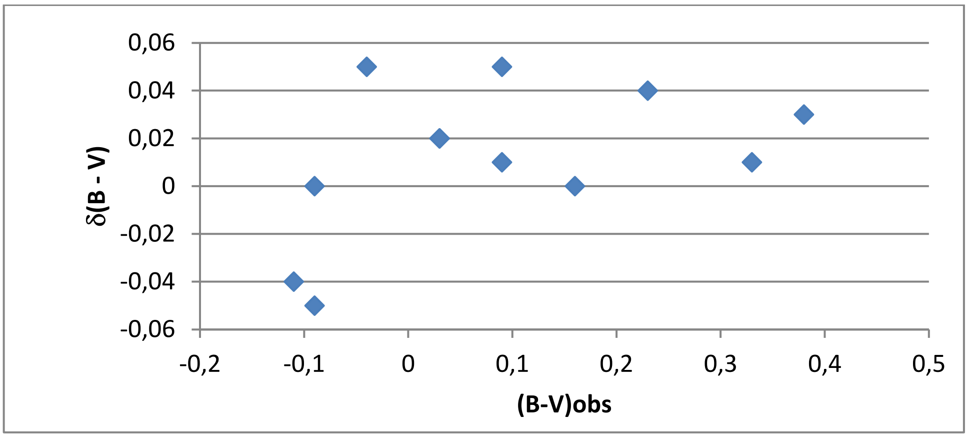

Figure 2 - Dependence of discrepancies δ(B - V) from color-index (B - V)

Table 3 - Comparison with the observed photometric data

No.	HD or BD	n	Vobs	Vcal	δV	(B-V)obs	(B-V)cal	δ(B-V)
1	BD+01 2668	8	10.29	10.26	-0.03	-0.09	-0.09	0.00
2	BD+02 2711	5	10.26	10.29	0.03	-0.11	-0.15	-0.04
3	BD+02 2790	3	10.11	10.11	0.00	0.03	0.05	0.02
4	HD136161	4	8.89	8.86	-0.03	0.33	0.34	0.01
5	HD151355	7	8.85	8.85	0.00	-0.09	-0.14	-0.05
6	HD162628	3	8.28	8.09	-0.19*	0.16	0.16	0.00
7	HD174648	5	8.81	8.82	0.01	0.09	0.10	0.01
8	HD185296	5	9.68	9.65	-0.03	0.23	0.27	0.04
9	BD -03 4950	5	10.00	10.00	0.00	0.09	0.14	0.05
10	BD+01 4436	4	9.99	10.01	0.02	0.03	0.06	0.02
11	HD215112	4	8.25	8.20	-0.05	-0.04	0.01	0.05
12	BD+02 4661	6	10.05	9.83	-0.22*	0.38	0.41	0.03

n - number of observations
*- stars with the big discrepancies δV

For three stars, we compared the observed energy distributions in their spectrums with the distributions that are calculated from photometric data. The method of calculating the distribution of energy in spectra of stars (absolutization) is set out in works [8, 9]. It can be used in the absence of data on energy distribution in spectra of stars selected as standards. According to figures 3-5, there are significant differences between observed and calculated energy distributions for the same stars, especially in the ultraviolet region. Discrepancies there are not only in the values themselves, but also in the course of distribution curves. These are primarily due to the significant difference in the course of normal energy distribution curves in the ultraviolet region for the stars of the early spectral classes. In addition, in this region it is more difficult into account interstellar absorption.

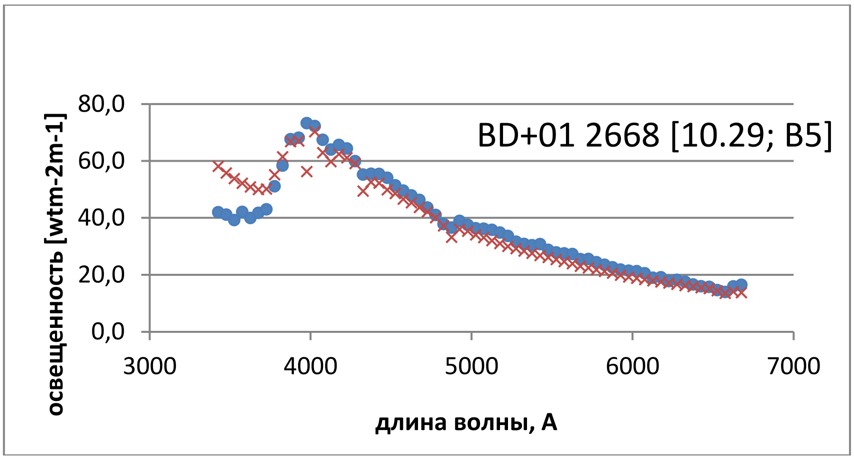

Figure 3 - Energy distribution in spectra BD +01 2668. • - observed, × - computed

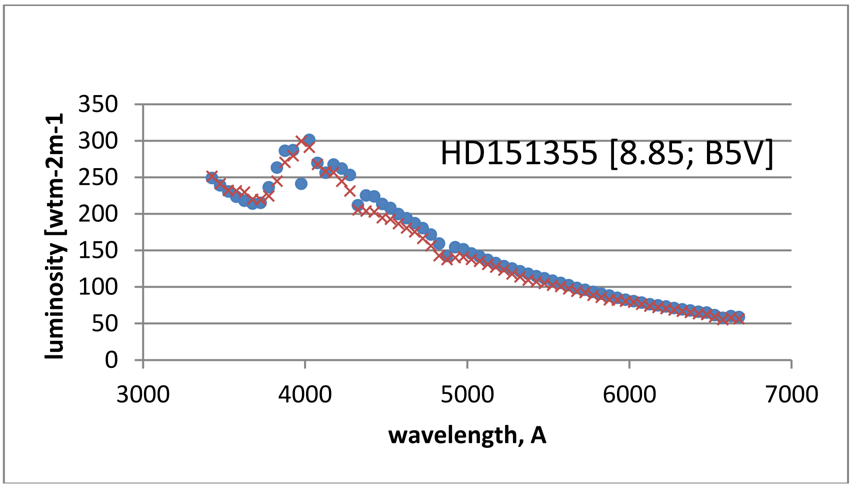

Figure 4 - Energy distribution in spectra HD151355. • - observed, × - computed

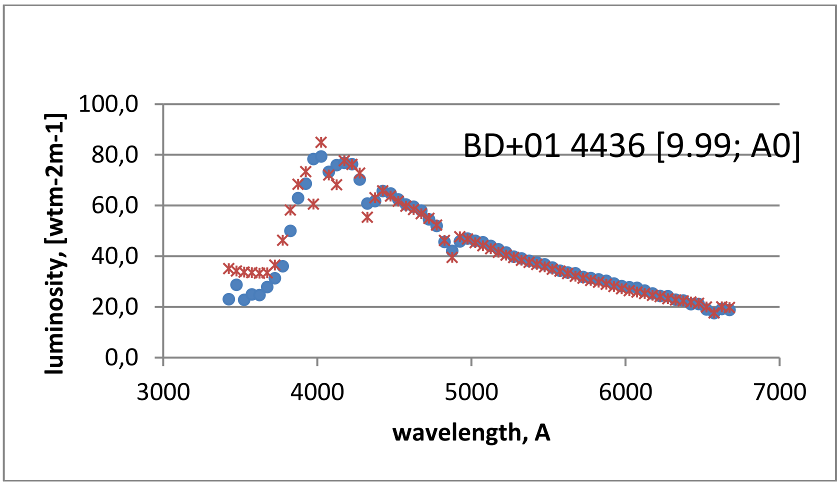

Figure 5 - Energy distribution in spectra BD +01 4436. • - observed, × - computed

In conclusion we let's make a critical remark concerning of task of the creation spectrophotometrical standards. It would seem that due to the mass introduction into astronomy of CCD cameras, allowing to

automate both the process of observations and their processing, the task of creating spectrophotometric standards should be solved much faster. However currently a works on their creation are very small. There are several reasons. One of them is the unpopularity of this kind of investigations which certainly does not promises any discoveries. At the same time, they require a lot of time, good photometric nights, strict adherence to the methodology, stable operation of the equipment. Therefore, despite their importance, they are unattractive even among astronomers, especially the young. Of course, in the end, such a network of spectrophotometric standards will be created with the help of space telescopes. However, no such mission has been planned so far. And, apparently, it will have to wait a long time.

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8^m- 10^m СПЕКТРОФОТОМЕТРЛІК СТАНДАРТТАР III. 12^h ден 24^h ЭКВАТОРЛЫҚ АЙМАҚ

Аннотация. Бұл жоспарланған кезекті жұмыстың үшінші мақаласы, спектрофотометрлік аралық жарқырау стандарттарын құруға арналған. 8^m-10^m жұлдыздық шамадағы 12 B-A жұлдыздар үшін көзге көрінерлік аймақтағы спектрлеріндегі абсолютті энергияның таралуы көрсетілген. Зерттелген жұлдыздар 12^h ден 24^h аралықтағы тура шарықтауда аспан экваторына көлбеу ($\delta = \pm 3^\circ$) орналасқан. Екінші жұмыстағы жұлдыздармен бірге олар аралық жарқыраудың экваторлық стандарттар жүйесін құрайды. Спектрдің көрінерлік аймақтағы 8^m-10^m жұлдыздық шамадағы спектрофотометрлік стандарттардың жалпы саны екі жұмыстың арқасында екі есеге өсті. Энергияның таралуы 340нм–660 нм аймағында зерттелді, алынған мәліметтердің спектрлік ажыратылымдылығы 5нм, ал алынған мәліметтердің салыстырмалы орташа квадраттық қателігі 2-ден 5% -ға дейін. ЗБА-камерасымен жабдықталған дифракциялық спектрографтың көмегімен АЗТ-8 және Цейсс-600 телескоптарында бақылаулар орындалды. Аппаратура, бақылау әдісі, редукциялау және есептеулер алғашқы кезеңді екі жұмыста толық келтірілген. Зерттелген жұлдыздардың нәтижелері тікелей бақылаулардың және есептелген жұлдыздық шамаларды салыстыру арқылы дұрыстығы алдыңғы жұмыстардағыдай дәлелденді. Сонымен қатар, бірнеше жұлдыздар үшін спектрлеріндегі энергияның таралуы фотометрлік мәліметтер бойынша есептелді. Спектрлік класындағы жұлдыздар үшін ультракүлгін аймақтағы бақылау және есептеу шамаларының айырмашылығы 20-30% дейін жетуі мүмкін. Олар жақын спектрлік кіші кластардың ыстық жұлдыздардағы энергияның қалыпты таралуы қисықтарының үлкен айырмашылықтары мен спектрлік жіктеудегі қателіктерге байланысты. Мақаланың қорытынды бөлімінде стандарттар құру бойынша жұмыстың маңыздылығы мен өзекті еместігі туралы мәселе көтерілген.

Түйін сөздер: спектрофотометрлік стандарттар, экваториалық аймақ, спектрограф, жұлдыздар.

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СПЕКТРОФОТОМЕТРИЧЕСКИЕ СТАНДАРТЫ 8^m-10^m . III. ЭКВАТОРИАЛЬНАЯ ЗОНА ОТ 12^h до 24^h.

Аннотация. Данная статья является третьей из серии работ, посвященных созданию спектрофотометрических стандартов промежуточного блеска. В ней представлено абсолютное распределение энергии в видимой области спектра для 12 B-A-звезд 8^m-10^m. Исследованные звезды расположены равномерно вдоль небесного экватора ($\delta = \pm 3^\circ$) в интервале прямых восхождений от 12^h до 24^h. Совместно со звездами из второй работы данной серии они образуют систему экваториальных стандартов промежуточного блеска. Благодаря этим двум работам, общее число спектрофотометрических стандартов 8^m-10^m в видимой области спектра увеличилось более чем вдвое. Распределение энергии исследовано в интервале 340нм - 660нм, спектральное разрешение составляет 5нм, относительная с.к.о. полученных данных в среднем составляет от 2 до 5%, возрастая на краях исследуемого интервала до 7-8%. Наблюдения выполнены на телескопах АЗТ-8 и Цейсс-600 с помощью спектрографа с тороидальной дифракционной решеткой. Приемником излучения служила ПЗС-камера ATIC-490EX. Подробно аппаратура, методы наблюдений, редукций и вычислений описаны в первых двух работах этого цикла. Как и в более ранних работах, достоверность полученных результатов оценена путем сравнения вычисленных и непосредственно наблюдаемых звездных величин исследованных звезд. Кроме того, для нескольких звезд распределение энергии в их спектрах было также вычислено по фотометрическим данным. Различия в ультрафиолетовой области для звезд спектрального класса В между наблюдаемыми и вычисленными значениями могут достигать 20-30%. Они обусловлены большими различиями в ходе кривых нормального распределения энергии в звездах близких спектральных подклассов и ошибками в спектральной классификации. В заключительной части статьи затронут вопрос о важности и, одновременно, непрестижности работ по созданию стандартов.

Ключевые слова: спектрофотометрические стандарты, экваториальные зоны, спектрограф, звезды.

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