JOINT SPECTROPHOTOMETRIC CATALOGUE OF THE STERNBERG STATE ASTRONOMICAL INSTITUTE AND FESSENKOV ASTROPHYSICAL INSTITUTE: THE ANALYSIS OF COMMON STARS

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Abstract. The *Spectrophotometric Catalogue of the Sternberg State Astronomical Institute* contains 875 stars; 8 of them are standards.

The *Catalogue of the Fessenkov Astrophysical Institute* consists of 1123 stars. The data on the spectral energy distribution for about a half of these stars are published.

A comparison of energy distribution data for 473 common stars in the range 3200–7600 Å was made. Calibration of Alpha Lyr from Hayes (1985) was used for all the stars of both catalogues.

In difference of the previous publications the comparison includes much more stars and energy distribution data were corrected where necessary. The agreement between the corrected data is better than in the case of the earlier comparison. Reductional factors due to the instrumental effects were taken into account for 275 stars from the *Sternberg Institute Catalogue*. These factors are in the limits 1.01–1.04 and their mean value is 1.03.

The reductional factors for the stars from the *Fessenkov Institute Catalogue* are much larger: 1.06–1.12 with the mean 1.06–1.07. In this case the reduction factors were taken into account for all the stars of the catalogue except the brightest ones with $V < 2.0$.

The values of the differences between spectral energy distribution data for common stars in dependence of magnitude, spectral type, and wavelength are presented.

Almost two decades ago spectrophotometric observations of bright stars were started at the Alma-Ata Astrophysical Institute and Sternberg Astronomical Institute. The aim of these investigations is the creation of the spectrophotometric catalogs including spectral energy distribution data for a great number of stars of different spectral types and luminosities. These data are widely used in theoretical and applied research in many fields of astrophysics. The traditional field of energy distribution data application is using them as standards in the investigations of peculiar and variable stars.

From the very beginning of regular observations two identical spectrophotometers with concave gratings were installed at the Crimean Station of the Sternberg Astronomical Institute and Alma-Ata Astrophysical Institute. The method of information processing was the same. Eight early-type stars were used as standards, including α Lyr (Kharitonov *et al.*, 1978; Voloshina *et al.*, 1982).

Subsequently detailed investigations of spectral energy distribution of seven standards by means of the comparison with α Lyr were made independently in two institutions. The comparison of standard stars and α Lyr were done through observations with the

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minimum differences in air mass. As a result the system of spectrophotometric standards were created which is a base of energy distribution data for all the stars of both catalogs. The same spectral energy distribution for all the standards were used in both institutions (Kharitonov and Glushneva, 1978).

Now the *Spectrophotometric Catalog of the Sternberg Institute* includes 867 stars (without standards) with spectral energy distribution data in the range 3200–7600 Å and more than 200 stars – in the range 6300–10 800 Å. Spectral resolution is 18 and 35 Å correspondingly, energy distribution data are presented with a 50 Å interval.

The *Spectrophotometric Catalog of the Alma-Ata Astrophysical Institute* includes 1123 stars, 8 of them are standards. Energy distribution data are published for about a half of these stars (Kharitonov *et al.*, 1978). The data are presented with a 50 Å interval in the range 3200–7600 Å, spectral resolution is 18 Å.

473 stars are common for both catalogs.

For the construction of joint spectrophotometric catalog the analysis of common stars is a necessary task of paramount importance.

At the earlier stage of investigations the analysis of common stars carried out jointly (Glushneva and Kharitonov, 1978) showed that systematic differences exceeding 2% are absent between two spectrophotometric catalogs. Energy distribution data for the Moscow catalog were detected to be more than for the Alma-Ata one for an overwhelming majority of stars. For about 15% of common stars the differences between monochromatic fluxes exceed 12.6% (maximum value of permissible occasional difference with reliability $P = 90\%$). The picture of the spectrophotometric data agreement is 'spoilt' in the ultraviolet and red ends of spectral range, however, it is connected with poor flux at the red for hot stars and at the ultraviolet for cool stars, but at the effective wavelengths 4500 and 5500 Å the number of stars with considerable discrepancies exceeds 10%.

The results of the comparison of Moscow and Alma-Ata spectrophotometric catalogs are presented also at the *Spectrophotometry of Bright Stars* (Voloshina *et al.*, 1982).

One of the reasons of the differences between two catalogs data may be insufficient consideration of the instrumental effects discovered when inner homogeneity of each of the catalogs was investigated (Glushkova *et al.*, 1984; Glushneva and Ovchinnikov, 1982).

For elimination of these effects at the Sternberg Institute the analysis of stars which were observed with different amplifiers was done. On the basis of these observations reduction factors were obtained.

It appeared that corrections must be done only for 275 stars with $V > 2^m.5$ observed with the aplifier being in use till April 1973. For the observations having been done later when the amplifier was changed the reduction factors were not necessary.

The values of reduction factors are presented in Table I.

Table I shows that reduction factors are between 1.02–1.04 with the mean value 1.03. The dependence of reduction factors from star brightness has not been found for stars weaker than with $V = 2^m.5$. Energy distribution data on the magnetic tape were corrected where necessary.

TABLE I

Reduction factors K_λ for the Spectrophotometric Catalog of the Sternberg Astronomical Institute

Stars	3200–3700	4000–5000	5000–6000	6000–7000	7000–7600
All	1.01	1.03	1.03	1.04	1.04
B–F	1.02	1.02	1.02	1.04	1.04
G–M	1.00	1.03	1.04	1.02	1.04

For the estimation of the instrumental effects for stars of the *Alma-Ata Spectrophotometric Catalog* the observations of 150 stars of various spectral types and magnitudes were repeated with the new amplifier (Tereshchenko and Glushkova, 1987). More than for 900 stars energy distribution data were obtained with the old amplifier. Only from 1980 new equipment began to be in use for spectrophotometric observations at the Alma-Ata Astrophysical Institute.

Reduction factors in this case were obtained in the range 4000–6500 Å. They were found to have no dependence from wavelength in the limits of the accuracy of 1.03–1.04. However, the dependence of reduction factors from magnitude and in less degree from the standard which was used in the observation of each star as the object of comparison was seen obviously.

In consequence reduction factors for the Alma-Ata catalog were grouped in dependence from magnitudes of the star observed and the standard star.

The values of reduction factors are presented in Table II.

TABLE II

Reduction factors for the Alma-Ata spectrophotometric catalog

Standard stars	$V < 1^m$	1^m–2^m	2^m–3^m	3^m–4^m	4^m–5^m	$V > 5^m$
α Lyr, α Aql	1.00	1.01	1.04	1.06	1.08	1.12
α Leo, β Tau	1.00	1.00	1.02	1.06	1.08	1.11
γ Ori, η UMa						
α Peg, β Ari	1.00	1.00	1.00	1.03	1.06	1.06

For the majority of stars of the Alma-Ata catalog reduction factor is 1.06. Energy distribution data obtained at the Alma-Ata Astrophysical Institute were recorded at the magnetic tape and corrected where necessary.

The data of both spectrophotometric catalogs were transformed to α Lyr calibration published by Hayes (1985).

In the process of comparison of spectral energy distribution data for common stars double stars with differences between spectral types of the components exceeding a half of a type were excluded. Also a few variable stars with the limits of variability exceeding 0.1 did not take part in the comparison.

For common stars relative differences δ were calculated

$$\delta = 2\{[E^m(\lambda) - E^a(\lambda)]/[E^m(\lambda) + E^a(\lambda)]\} \times 100\%\ ,$$

where $E^m(\lambda)$ and $E^a(\lambda)$ are monochromatic fluxes for the Moscow and Alma-Ata catalogs correspondingly.

Mean values of δ were calculated in four spectral ranges: 3225–4075, 4075–5025, 5025–6025, and 6025–7025 Å, which correspond approximately to the effective wavelengths 3600, 4500, 5500, and 6500 Å.

Six stars were excluded from the consideration because of large differences $\delta > 15\%$. These stars are not variable ones and they need reobservations. In the ultraviolet some late-type stars did not take part in the comparison because of large differences connected with poor flux.

Mean values of δ in four spectral ranges were analysed in dependence on the magnitude and spectral type. Table III contains mean values of δ in dependence from spectral type in four ranges (in %). Spectral types of stars were taken from *The Bright Star Catalogue* (Hoffleit, 1982).

TABLE III

The dependence of the mean differences δ from spectral type (δ in %)

Sp.	3225–4075	N	4075–5025	N	5025–6025	N	6025–7025	N
O	−0.4	5	−0.8	6	0.0	6	−2.7	5
B	−0.7	102	−1.8	105	−0.1	105	0.1	98
A	0.8	110	−1.3	111	−0.1	111	0.3	109
F	1.2	47	−0.9	48	0.0	48	1.6	48
G	−3.9	26	−2.7	32	−0.1	32	−0.6	31
K	−2.6	71	−0.6	76	0.0	76	1.6	74
M	−6.9	20	−4.1	20	−0.1	20	0.8	20

N, the number of stars being in consideration.

The first line of Table III contains data on spectral ranges.

Table III shows that there are no systematic differences exceeding 0.1% for the spectral range 5000–6000 Å.

The mean of the absolute values of δ in the range 5025–6025 Å for stars of different spectral types is 5.4%.

No remarkable systematic differences between Moscow and Alma-Ata observations

TABLE IV

The dependence of the mean differences δ fro magnitude (δ in %)

Mag.	3225–4075	N	4075–5025	N	5025–6025	N	6025–7025	N
$V < 2^m$	0.2	14	0.8	16	0.0	16	2.6	16
$2^m < V < 3^m$	2.1	38	0.5	40	0.0	40	0.0	40
$3^m < V < 4^m$	−1.6	107	−2.4	111	−0.1	111	−1.1	108
$4^m < V < 5^m$	−0.9	155	−1.4	163	−0.1	163	0.3	158
$V > 5^m$	0.4	47	−1.0	48	0.0	48	5.1	43

exceeding the inner accuracy of each catalog exist. Some increasing of δ values in the ultraviolet for the late stars is understandable. It may be seen that for almost all spectral types the values of δ in the ultraviolet and blue ranges are negative and in the red-positive (except O- and G-stars), however, δ do not exceed 1% as a rule.

Table IV contains mean values of δ in dependence from the magnitude. M-stars were excluded.

Table IV shows that there are no remarkable differences between δ values for bright and faint stars. The maximum of δ is for the stars fainter than 5^m in the red. It may be understandable because there are about 80% B–F stars among them with the poor flux and, therefore, lower accuracy of the measurements in this range.

Another variant for δ determination was calculated including all the stars with variables and suspected variables. It was interesting to obtain this result because we tried to include to the catalogs nonvariable stars, however, many of them appeared to be variables or suspected variables. There are no qualitative differences in the distribution of δ according to spectral type and magnitude in this case. As in the first case for the range 5000–6000 Å δ do not exceed 0.1%. It is interesting to remark that for all M-stars δ values in the ultraviolet and blue are slightly less (-4.8% and -3.7%).

In conclusion we present the mean values of δ for all stars for Table IV (without M-stars) in four spectral ranges.

3225–4075	*N*	4075–5025	*N*	5025–6025	*N*	6025–7025	*N*
−0.6%	361	−1.3%	378	−0.1%	378	0.5%	365

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