CORRECTION OF THE SCALE OF ASTROPHYSICAL QUANTITIES

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ABSTRACT. To construct the correct scale of astrophysical quantities a simple procedure of determination of self-consistent and interdependent with each other mean values of basic characteristics for every spectral subclass is offered.

Key words: Stars: the scale of astrophysical quantities.

1. Introduction

It is not necessary to explain anybody how useful the scale of astrophysical quantities turns out to be in different astronomic investigations. But the following question is to the point : are the scales' data and the approach used to construct them reliable? As investigations show, there are grounds to raise such question. So, when comparing with each other the already existing scales of the same luminosity class, the following peculiarities are revealed:

1) distinctions in the mean values according the very spectral subclass of one scale turn out to be essential towards another one, and evidently exceed the errors of determination of basic characteristics themselves.

2) strange and illegitimate behavior of some values, derivatives (combinations) of basic characteristics, along spectral sequence from hot stars to cold ones.

3) absence of precise and single-valued connection between such values as mass of a star and its luminosity.

The list of only just these peculiarities gives us a reason to doubt in the reliability of data the existing scales have. That's why, to construct a correct scale it is necessary to study out the reasons that cause an uprise of these peculiarities, and to find the ways of their removal. Right this is the aim of the present article.

In this case we'll not touch the ways that determine basic characteristics of individual stars (they are well-known) and the approach of the scale construction as a whole (every investigator uses his own methods with this purpose (see e.g. Allen, 1997; Strajzys and Kuriliene, 1981), but we'll consider only several details of this problem. In particular, we'll analyze the procedure of stars selection with the purpose of sample formation and the receipt with its help the mean values of basic characteristics for the given subclass. Under the sample we understand a collection of stars having the same MK-characteristics. Further, to shorten the notation we'll write "the mean values of basic characteristics" implying by this that these values refer to the given spectral subclass of the given luminosity class.

2. Heterogeneity of the sample. Near values of basic characteristics.

Let refer to the analysis of the first peculiarity. Usually, to construct the scale of astrophysical quantities of the given luminosity class, investigators concentrate their attention on the receipt of one or at least two mean values of some basic characteristics, attracting with this purpose such types of stars whose corresponding characteristic (or characteristics) is determined unhesitatingly. However, in practice everything is more complicated. For example, to construct the scale of effective temperatures, the stars with surely determined absolute power distributions in their spectra and angular diameters are usually attracted (see, e.g. Morton and Adams, 1968; Hayes, 1978). However, the number of such well-known stars is in fact not great, and it is often not enough to consider the obtained values as the reliable and typical for the given subclass. This remark remains reasonable also for the mean values of other basic characteristics. It is necessary to add that the selection of stars into the sample is not strict. Essentially, except MK-characteristics there are no any other criteria controlling such selection.

The pictures 1 and 2 taken from Merezhin (2001) will help us to judge either the obtained mean values of basic characteristics are typical for the given spectral subclass or not. As an example, here are presented histograms for effective tempera-

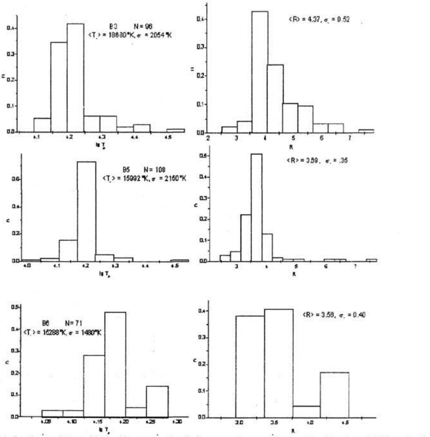

Figure 1: Distributions of T_e and R inside spectral subclass are shown. The luminosity class is V (see text).

ture T_e and radius R (picture 1), as well as mass M and absolute star magnitude M_v (picture 2) inside spectral subclass for stars of V luminosity class. To demonstrate this we confine ourselves by subclasses B3, B5 and B6. The total amount of stars (N) participated in the formation of mean values T_e, R, M and M_v is indicated at pictures for each sample. It is possible to find the algorithm of construction of such histograms in the quoted article, and we'll not recur to it here. When constructing these histograms, the only criteria according to which we reckoned the star in one or another spectral subclass was its MK-characteristics obtained directly by the observational data.

As it is shown on pictures 1 and 2, the spread in values of every from quantities T_e, R, M and M_v inside of any from the presented subclasses, turns out to be a considerable one and noticeably exceeds the interval of $3 \times \sigma_Q$ width that in fact determines the reliability of $\langle Q \rangle$'s mean value, where Q is any of quantities under consideration, and σ_Q is an average square error of determination of $\langle Q \rangle$ value. If take into account the value of σ_Q determination error itself of Q characteristic, then the difference between its minimum and maximum values denominated in this measure turns out to be very large inside the given subclass. So, for subclass B3 the determination error σ_T of $\langle T_e \rangle$ value is equal to ± 2054 K, and determination error σ_M of $\langle M \rangle$ value is $\pm 1.27 M_\odot$. Then, as it shown on pictures 1 and 2 the difference between minimal and maximum values of T_e inside B3 subclass turns out to be equal to ≈ 18500 K ($\sim 9\sigma_T$), and the difference between minimum and maximum values of mass $- 12.7 M_\odot (\sim 10\sigma_M)$.

It is clear that because of big variation of basic characteristics values and small amount of stars attracted to such determinations, it is rather problematically to consider the received value as a typical one for the given subclass. At least we can advance two arguments supporting the justness of this remark. The last remark is equally related to any from characteristics considered here and to the effective temperature as well. Firstly, errors of determination of basic characteristics which are inevitably contained in every star, will influence on the mean value formation. Secondly, values of characteristics of the same stars received by different investigators are noticeably differ from each other, and this may tell on the mean formation. Such differences are conditioned by the usage of different methods of observation and determination of basic characteristics of individual stars, by dissimilarity of ways of attaching the observational data to different standards and calibrated dependencies, by the use of different standards and calibrated dependencies and methods of observational data processing. However we shouldn't think that the contribution of this component will be meaningful, and the differences between the characteristics values of the same stars received by different investigators will be dramatic. As investigations show, these differences do not usually fall outside the intervals equaled in the trebled value of determination error of characteristics themselves. This is conditioned by the following circumstance – in spite of the variety of methods of observation and determination of basic characteristics, methods of observational data processing and their attaching to standards and calibrated dependencies, all of them do not differ from each other in principle, and eventually lead to similar results. Nevertheless, when the number of stars in a sample is not big, this circumstance should be taken into account.

The appearance of variation of basic characteristics inside spectral subclass is the statement of a well-known fact that the stars having even equal MK-characteristics can differ from each other in their basic characteristics (Underhill, 1982). This variation as it follows from the data on pictures 1 and 2 turns out to be considerable, and it should be taken into account when constructing the scale of astrophysical quantities. In principle, except stars which are the typical representatives of the given spectral subclass, there in a sample can be presented episodic stars, such as: a) the very evolved objects; b) the durable variable stars which happened to be in the given subclass temporarily at some phase of the sparkle and evolution changing; c) the stars having though cognate MK-characteristics but yet slightly different from the standard ones; d) the objects having values of MK- and basic characteristics as if similar with the standard ones only through the influence of the perturbing factors on their pressure-temperature field structure (e.g., rotation and turbulence) and others. Investigations show that the analogous spread in values of any from basic characteristics is detected in other not represented here spectral subclasses of V luminosity class, and in IV and III luminosity classes of stars as well.

It is clear that in order to correct the above-stated and to find the stable solution, the sample should contain if possible a big number of members that is computing in some tens. However, according to the objective and subjective reasons such approach fails to be realized in practice. That's why a big variety of stars types inside spectral subclass from one hand, and their small number participating in formation of the mean value, as well as highhandedness in their selection and the absence of strict selection criteria from the other hand, are the main sources of appearance of the peculiarity that was the first to be enumerated in the previous paragraph.

3. Quantities g_{dyn} and v_{cr} as the indicators of the reliability of determination of the mean values of basic characteristics. Mass-luminosity correlation

We can judge about the reliability of the obtained values with the help of derivatives of basic characteristics by studying their behavior according to changes in characteristics that form these derivatives. As the behavior of derivatives is known beforehand, its bare change will serve us as the evidence of the fact that the derivatives together with the mean values of basic characteristics are not correct. In other words, it is possible to choose such values that will serve as the indicators which allow to judge about the reliability of the data from the scale of astrophysical quantities.

As an example, let limit ourselves by studying the behavior of such derivatives as dynamic gravity $g_{dyn} = (\frac{G \times M}{R^2})$ and critical rotation velocity v_{cr}. These are the functions of M and R characteristics, and therefore they give us a possibility to judge about the reliability of <M> and <R> values determination. If we are dealing with the single stars, then as it is known (see, e.g., Sinnerstad, 1980) their mass is estimated according to the evolutionary tracks. The effective temperature and the absolute star value (or its luminosity) are attracted with this purpose. Then due to g_{dyn} and v_{cr} quantities we can judge indirectly about the reliability of <T_e> and <M_v> (or <L>) values determination.

In order to get the formulae for estimating velocity v_{cr}, let use a well-known expression (Huang and Struve, 1963).

$$\frac{\Omega_{cr}^2}{2 \times \pi \times G \times \rho} = 0.36075 \quad (1)$$

If $\rho = \frac{M}{4\times\pi\times R_{cr}^3\times 0.180373}$, $v_{cr} = \Omega_{cr} x R_{cr}$ and $R_{cr} \approx \frac{3}{2}\times R_p$, then after small transformations we find the necessary folmulae

$$v_{cr} \approx 2.10873\times10^{-4}\times\sqrt{\frac{M}{(1-\beta)\times R}}, \qquad (2)$$

where Ω_{cr} denotes the critical rotation angular velocity; R_{cr} is the critical radius; ρ is the mean density; and G is the constant of gravitation.

When deducing the formulae (2) we used the correlation $R_p = R_0\times(1-\beta\times[\frac{v}{v_{cr}}]^2$ taken from Maeder and Peytremann (1970) that ties together polar radius R_p of the rotating star with radius R_0 of the non-rotating star of the same mass. The constant β is equal to 0.030 if $M>2M_\odot$, and is equal to 0.024 when $M<2M_\odot$ and where $M_\odot$ is mass of the Sun.

Table 1: The variation of g_{dyn} and v_{cr} quantities along the spectral sequence. The luminosity class V

	Our scale		The scale of Strajzys and Kurielene		Popper's scale		Renewed scale	
Sp	g_{dyn}	v_{cr}	g_{dyn}	v_{cr}	g_{dyn}	v_{cr}	g_{dyn}	v_{cr}
O5-5.5	5660	554	8083	756	-	-	4509	518
O6-6.5	5702	525	7543	698	-	-	6698	549
O7-7.5	6596	537	7370	651	9942	617	6675	545
O8-8.5	6918	528	7545	615	10301	610	7196	538
O9.5	7738	557	9742	728	6803	509	7274	538
B0	8338	558	10413	720	6375	482	7592	523
B1	8452	489	10173	642	7714	490	8119	473
B2-2.5	8821	485	11680	620	8702	477	9280	470
B3	9996	483	11415	565	12220	463	10366	449
B4	10758	448	12262	460	10590	440	10679	434
B5	10882	463	13169	445	16079	468	10923	429
B6	10913	455	12232	420	13211	424	11135	425
B7	11313	410	11684	397	-	-	11921	421
B8	11288	408	11955	388	15457	409	12366	416
B9-9.5	10278	370	10656	362	11781	377	12938	386
A0	10621	361	11693	358	15334	391	14219	382
A1	10441	356	13107	366	10203	349	14357	378
A2	14127	374	14378	370	20794	393	14754	378
A3	14792	376	16502	379	13551	364	14938	377
A4-5	16428	376	17280	375	12793	358	15684	372
A7	17489	375	18950	375	3784?	272	18107	378
F0	18328	371	19859	366	11822	329	15704	353
F2	20133	374	18534	354	11865	326	21262	376

Let consider now a well-known to us behavior of g_{dyn} and v_{cr} quantities along spectral sequence, viz.: gravity g_{dyn} must rise and velocity v_{cr} must decrease from hot stars to cold ones. The results of this analysis are shown in Table 1 within spectral range from O5 to F2 for the stars of V luminosity class according to the data of our scale, the scale of Straizhys and Kuriliene (1981) and the Popper's scale (1980) of masses and radiuses.

Everybody can get acquainted in details with the method of constructing the scale of Straizhys and Kuriliene in the work of reference. Popper's data were received on the ground of measuring M and R values of the components of close binary stars. As for our scale, we can mark the following. In order to construct this scale we attracted 152 stars with the reliable photometric and spectrophotometric data. The stars' values T_e, M_v and B.C. were determined according to D-test (Merezhin and Shaimukhametova, 1992) with the help of Kuruts' data (1979). The radiuses were measured under the formula (Allen, 1977)

$$\lg M = a_2 \cdot M_{bol} + b_2 \qquad (3)$$

and masses were derived from the evolutionary tracks of Maeder and Megnet (1978). The quantities T_e, R, M, M_v and B.C. of every star were used then to obtain their mean values.

Taking into account a smooth course of changing of characteristics R and M along spectral sequence from hot stars to cold ones, we have a right to anticipate the analogous change of g_{dyn} and v_{cr} quantities along the same sequence. However, it is not so. As it follows from the data of Table 1 (see columns No. 2, 4 and 6) for gravity g_{dyn}, though generally it is detected a tendency to the increase in its value from hot stars to cold ones, nevertheless change of g_{dyn} value along spectral sequence evidently bears an irregular character. We see that change is not smooth, and in some sections of the sequence a change of gravity g_{dyn} turns out to be antithetic the general tendency. The same behavior is discovered at the velocity v_{cr} (see columns No. 3, 5 and 7). It is clear that such strange and illegitimate behavior of g_{dyn} and v_{cr} quantities is impossible to be explained by the action of some perturbing factors, it is evidently conditioned by the fact that we have incorrect knowing of $\langle R\rangle$ and $\langle M\rangle$ values in separate sections of spectral sequence. This fact is confirmed by the circumstance that the character of irregularity and its amplitude are not constant and are changed from one scale of astrophysical quantities to another. It is important to underline that irregularity is kept regardless of the method the quantities $\langle R\rangle$ and $\langle M\rangle$ were determined – either it was made together with the formula (3) by the use of evolutionary tracks or with the help of close binary stars. As investigations show such peculiarity of behavior of g_{dyn} and v_{cr} quantities is observed in all scales of V, IV and III luminosity classes without exception. Let us nominally call this behavior of derivative quantities as the internal inconsistency of astrophysical quantities. Right this inconsistency conditions the second peculiarity.

In the light of the above-stated the third peculiarity finds its own explanation. It is completely connected with mass-luminosity correlation and allows to judge about the reliability of <M> and <L> values determination. As investigations show (see, e.g. Schwarzschild, 1961) there are strong reasons confirming the existence of connection between the star's mass and its luminosity. Usually this dependence is presented as a linear correlation (Aller, 1955)

$$lg\,M = a_1 \times lg\,L + b_1 \quad (4)$$

or (Schwarzschild, 1961; Aller, 1955)

$$lg\,M = a_2 \times M_{bol} + b_2, \quad (5)$$

where a_i and b_i (i = 1, 2) are the coefficients subjected to determination. Here quantities M and L are expressed in the sun measures.

As investigations show such form of dependence between quantities M and L (or M and M_{bol}) is kept up to the III luminosity class, and only a_i and b_i values undergo changes from one luminosity class to another. Not going into details of the problem as a whole, let consider only such part of the problem that refers to a_1 and b_1 values determination. As it is well known (see, e.g., Demircan and Kanraman, 1991) the quantities <M> and <L> take part in their determination.

Table 2: The values of a_1 and b_1 coefficients according to the literature and our data

№	a_1	b_1	References
1	0.298	+0.030	Deich (1962)
2	0.262	+0.056	Russll and Moor (1940)
3	0.255	-0.013	Parenago and Masevich (1951)
4	0.260	-0.022	Our scale
5	0.270	-0.019	Demircan and Kanraman (1991)
6	0.255	-0.002	Demircan and Kanraman (1991)
7	0.320	-0.013	Eggen (1956)
8	0.300	-0.145	Svechnikov (1969)
9	0.258	+0.021	McCluskey and Kondo (1972)
10	0.263	+0.011	Heintz (1973)
11	0.358	-0.220	Kopal (1978)
12	0.272	-0.046	Cester et al. (1983)
13	0.240	-0.001	Griffins et al. (1988)

Let refer to the data of table 2, where a_i and b_i values are cited for the stars with measurable mass values, and where are indicated the references to the works from which these data were taken. As the literature data show, the errors of a_i and b_i coefficients determination are on the average equal to ≈ ±0.010 and ≈ ±0.012, respectively. To demonstrate graphically the spread in a_i and b_i values received by different investigators, let use the scale where the units of measurement are σ_a and σ_b themselves. The measurements received by different investigators, e.g. a_i value, in such scale noticeably differ from each other, and the spread in their values goes within the interval of $\approx 12 \times \sigma_a$ width. Much bigger differences are detected when estimating b_i coefficient. In this case the spread in its values goes within the interval of $\approx 23 \times \sigma_b$ width. The cited values of the intervals' width evidently exceed the admissible limits of the intervals correspondingly equal to $3 \times \sigma_a$ and $3 \times \sigma_b$, that in fact determine the reliability of the found a_i and b_i values. Here: σ_a and σ_b are the errors of determination of a_i and b_i values, respectively.

So we can state that a_i and b_i values received by different investigators differ noticeably from each other. Besides, b_i value in some cases is positive, and in others is negative. This allows to make a conclusion about the instability of the received solutions and about the unreliability of determination of <M> and <L> values, as well as about the absence of clear connection between M and L quantities.

4. Correction of the scale of astrophysical quantities

As it follows from the above-stated, a traditional approach used to construct the scale of astrophysical quantities requires to be corrected. To fulfill this correction let refer to pictures 1 and 2. These pictures suggest us one of the possible variants of its realization. We suppose that the correction should be made in two steps. The first one concerns the sample as a whole itself. We just add that it is not necessary to impose any rigid restrictions on its formation. For the sample to be a respectable one, a selection of members must be rather mild, and any stars having even peculiarities in their spectra can be present there. (Here the similarity of MK-characteristics of the sample members have still a great importance. In this case such factor as subjectivity in stars selection is excluded). But the stars with a very quick change of shine can be the exception.

To analyze the sample at the second step, we can offer the following algorithm. Let us have the sample, for each member of which there are known its basic characteristics. Then, for each characteristic Q from the total set of Q quantities we choose its maximum and minimum values and determine a width of the interval inside which all existing Q values of the sample under investigation must be located. Thereafter, this interval is divided to equal sections and we construct a histogram in the same way as it was made in the second paragraph of the present article. The length of a section is determined a'priory with consideration of all members in the sample and the correctness of determination of Q characteristic under investigation. For example, we can take quantity σ_Q as a length of such section. These histograms will not differ in their form from those shown on pictures 1 and 2. That is why we return to these pictures again. We see that a certain similarity of distributions' forms of characteristics presented here is noticeably detected. Each distribution has the maximum.

Namely, the major and considerable part of stars from their whole collection of the given sample is centralized at a comparatively narrow section of each histogram. It is clear that the stars having close to each other values of Q characteristics are grouped near the maximum of distribution. On this basis we consider that:

(a) stars grouping near the maximums of distributions for different basic characteristics can be referred to the typical representatives of the given spectral subclass;

(b) stars distant far from the maximum in the same distributions are rather not typical; and according to different reasons they accidentally happened to be in the sample under investigation.

As an example, let analyze the sample of spectral subclass B3. If we refer to the distribution according to the effective temperature, then we may consider the stars having T_e values inside $14125\,K<T_e<17783\,K$ interval to be typical for this subclass. While the stars whose temperatures must have either $T_e<14125$ K or $T_e>17783$ K values should be referred to (b) group. The analysis of distribution according to radius leads us to the conclusion that the stars found inside the $3.6R_\odot<R<4.6R_\odot$ interval should be reckoned in (a) group, and the objects having R, $R<3.6R_\odot$ or $R>4.6R_\odot$ values should be referred to (b) group. For distributions according to mass and absolute star value, the stars with M and M_v values existing inside intervals $5.0M_\odot<M<7.0M_\odot$ and $-1^m.00<M_v<-1^m.80$ should be referred to (a) group, and the stars whose M and M_v values turns out to be either $M<5.0M_\odot$ or $M>7.0M_\odot$, as well as either $M_v<-1^m.00$ or $M_v>-1^m.80$ are referred to (b) group. It is not difficult to make the analogous analysis for the stars of B5 and B6 spectral subclasses.

Naturally, to find the mean values of any from basic characteristics it is better to use the stars which can be considered typical for the given spectral subclass with more certainty. It follows from the above-stated that more suitable to this aim are the stars grouping near the maximums of distributions. Then, as one of the selection criteria it is possible to use a narrow section near the maximum of distribution of Q characteristic which allows to separate typical stars from accidental ones in the sample under investigation. To obtain the mean values of basic characteristics, there should be used only the stars of (a) group, and the stars of (b) group can not be taken into consideration and can be excluded from the further analysis. We expect that in this case the objects grouping at a comparatively narrow but rather noticeable section of distribution admit us to get constant solutions with small errors. Length of a section can be changed at the investigator's will. It is clear that such criterion is impossible to be considered as a strictly well-founded one. That's why, in order to be sure in the correctness of partition of stars of the sample to (a) and (b) groups, it is preferably to use at one time several distributions for different basic characteristics. In perfect case we expect that the same stars will be grouping in each of such distributions near the maximum.

The last remark requires an additional explanation. As practice shows, the appearance of the same stars near the maximum of distribution for each from T_e, R, M and M_v quantities for B3, B5 and B6 subclasses is really observed in most cases. However, sometimes it is detected that in the same distribution the objects according to one of these quantities turns out to be near the maximum, and according to the other ones – not at all. In the last case basic characteristics of these objects are either wrong determined or they are just not typical representatives for the given subclass. That's why, to correct the indefiniteness they can be attributed to (b) group and excluded from the further analysis. Namely, we have a possibility to enforce the control for the sample members selection.

The reliability of determination of the mean values of basic characteristics after the use of every from the specified steps must be executed by indicators. By way of control it is suggested here to use even such indicators as dynamic gravity and critical rotation velocity. Right smooth increase and decrease of g_{dyn} and v_{cr} quantities along spectral sequence from hot stars to cold ones without any irregularities, will indicate us that the obtained mean values of characteristics are correct. However, such selection of indicators is not obligatory. In principle, it is possible with this purpose to attract other indicators derived from basic characteristics having a well-known behavior along spectral sequence, or very attractive peculiarities according to which it would be also possible to judge about the reliability of the obtained results. All this will strengthen the reliance in the data of astrophysical quantities scale.

It is clear that if investigator takes into consideration all stars of the sample, the mean value of any basic characteristic found by him, must differ from the analogous mean value of the same characteristic obtained by the correction procedure. The mean derived by traditional approach will be dislocated to the right or to the left from the mean determined by the correction procedure. The extent of dislocation (according to the module) is determined as a difference between the mean values obtained by two approaches. It depends upon a width of the interval inside which the whole set of values of basic characteristic Q (which we have in our disposition) is located. The direction of dislocation will depend on what kind of "tail" from the maximum of distribution, from the right or left sides, is more extended.

Table 3: In good repair scale of astrophysical quantities for the luminosity classes V + IV

Sp	N(n)	$<T_e>$	$<T_e>$	$<R>$	$<R^c>$	$<M>$	$<M^c>$	$<\lg L>$	$<\lg L^c>$	$<M_v>$	$<M_v>$
O5	8(3)	41155	39505	11.36	12.43	26.67	25.44	5.52	5.53	-5.64	-5.58
O6	15(5)	37049	37464	10.10	9.40	21.24	21.61	5.24	5.20	-5.32	-5.38
O7	10(3)	36117	37450	9.14	9.30	20.12	21.08	5.11	5.19	-5.15	-5.36
O8	18(7)	32903	34720	8.43	8.40	17.95	18.54	4.88	4.97	-4.59	-4.90
O9	20(7)	32380	30900	8.60	8.32	17.58	18.38	4.83	4.76	-4.48	-4.22
B0	32(9)	29234	29669	7.87	7.54	15.71	15.76	4.61	4.60	-3.98	-4.02
B1	59(15)	24968	24627	6.58	5.77	11.44	9.87	4.18	4.04	-3.30	-3.19
B2	31(9)	21459	23170	5.48	5.43	8.90	9.44	3.76	3.88	-2.47	-2.90
B2.5	29(8)	19782	18625	4.66	4.58	7.56	7.50	3.48	3.36	-2.09	-1.84
B3	96(42)	18680	18297	4.37	4.07	6.97	6.27	3.32	3.22	-1.68	-1.77
B4	38(14)	16650	16430	3.90	3.69	5.78	5.31	3.02	2.94	-1.38	-1.22
B5	108(54)	15992	15598	3.69	3.53	5.41	4.97	2.90	2.82	-0.98	-1.09
B6	71(30)	15288	14508	3.56	3.40	5.05	4.70	2.80	2.66	-0.80	-0.78
B7	42(12)	13618	13156	3.33	3.11	4.29	4.21	2.54	2.42	-0.57	-0.50
B8	46(14)	12566	12798	2.94	2.92	3.64	3.85	2.29	2.31	-0.38	-0.44
B9	49(15)	11078	10703	2.70	2.52	3.07	2.90	2.00	1.88	0.06	0.16
B9.5	25(9)	10294	9986	2.45	2.29	2.71	2.56	1.78	1.67	0.34	0.45
A0	23(9)	9840	9620	2.32	2.15	2.59	2.40	1.66	1.55	0.52	0.64
A1	15(5)	9454	9423	2.29	2.09	2.39	2.39	1.58	1.49	0.80	0.79
A2	16(7)	9112	9176	2.22	2.03	2.29	2.03	1.49	1.42	1.07	1.09
A3	13(5)	8796	8971	2.07	1.99	2.15	2.16	1.36	1.36	1.29	1.20
A4-5	9(4)	8446	8545	1.82	1.85	1.97	1.96	1.18	1.22	1.68	1.52
A7	8(3)	8007	7878	1.75	1.65	1.81	1.80	1.06	0.98	1.92	2.03
F0	6(2)	7320	7165	1.58	1.66	1.57	1.58	0.81	0.82	2.30	2.46
F2	4(3)	6674	6552	1.57	1.39	1.39	1.39	0.64	0.51	3.34	3.46

In principle, b_1 and b_2 coefficients in the formulae (4) and (5) must be absent in order not to break the equality when M=1 and L=1. Otherwise, the disruption of mass-luminosity correlation takes place. If the coefficient is really $b_1 \neq 0$, then as it is not difficult to make sure, the Sun turns out to be 10^{b_1} times brighter than it should be judging by its mass. In other words, the mean star of V luminosity class that has a mass equal to that of the Sun, will be weaker than the Sun for $2^m.5 \times b_1$ stars quantities, as well as will have rather less dimensions and more density than the Sun has (Russell and Moore, 1940). That's why it would be interesting to ascertain the situation with coefficients b_1 and b_2 and their physical sense. However, we are not succeed yet in finding any concrete recommendations to solve this problem in the frames of the suggested correction procedure. Nevertheless, we hope that the solution of the problem will be found in case the exactness of $<M>$ and $<L>$ values determination will increase.

Of course, from the formal point of view the offered approach is impossible to be considered as a perfect one. But it can be quite acceptable in practice. Having even the unrepresentative sample of stars which the investigator succeeded to attract with the purpose of constructing the scale of astrophysical quantities, the correction procedure, as it seems to us, is still necessary to be held. Otherwise, it will be difficult in future to depend upon the obtainment of the reliable and steady results.

In principle, we can assure in reliability and steadiness of the results which are obtained by the correction procedure, in the following way. It is necessary to take other stars that did not participate in the construction of astrophysical quantities scale, and to construct a new scale with them according to the methodic described above. Eventually we should come to the results identical to those obtained earlier by the other set of stars. Our assurance is grounded on a quite obvious position that we should always obtain equal mean values of basic characteristics regardless of the set of stars we use. That is quite understandable as the selfsame set of mean values of basic characteristics should always answer the objects having equal MK-characteristics in the frames of the given luminosity class and the given subclass.

5. Results

To demonstrate the correction procedure let refer to the stars of V and IV luminosity classes. We'll limit ourselves by constructing a scale in the spectral range from O5 to F2. Let unite the stars of these luminosity classes for the sample to be representative. The results of these investigations are presented in Table 3 where there are the data obtained by traditional (in columns No. 3, 5, 7, 9 and 11) and other methods offered by us (in columns No. 4, 6, 8, 10 and 12). In the last case when constructing the histograms it was used one of the criteria of dividing the members of a sample to (a) and (b) groups, viz. we choose the section near the maximum of distribution which extension for each from T_e, lg$L$, R, M and M_v characteristics changed according to the number of N members of the sample and according to the exactness of their determination. It is natural that under such division a number of stars n participated in formation of the mean value, turns out to be visibly less than number N. In column No. 2 of table 3 a number of members of each sample found in group (a) is indicated in round brackets. As investigations show, the higher is the exactness of basic characteristic determination in practice and the more stars are in the sample, the narrower can be chosen the section near the maximum to find the mean value. We will nominally call the scale of astrophysical quantities received by the use of the correction procedure – the renewed scale.

The way of obtaining basic characteristics of stars that were used to construct the scale of astrophysical quantities, was traditional (Merezhin, 1994 a, b). Namely, the magnitude V, the color indicators U-B and B-V of the UBV system, the excess of color E (B-V) and the angular diameter D were in the first place collected for each member of the sample according to the published data. All these data are necessary for us to derive an absolute energy distribution in the spectrum of the used star. The quantities V, U-B and B-V were mainly taken from Mermilliod and Nicolet (1977). A standard energy distribution in the spectrum of a star with MK-characteristics A0V and V=0 were obtained according to data of Vega's absolute calibration performed by Arkharov (1989). Then, using D-test (Merezhin and Shaimukhametov, 1992) there were received the self-consistent and interdependent with each other T_e, M_v and B.C. values that form a reliable base to find other basic characteristics of a star. In cases when the data for D-test usage were not enough, we used the traditional ways of determination of the quantities we are interested in. As a result, a homogeneous set of data was received, because all basic characteristics of stars were found by the same means and according to the single methodic.

Let now refer to the analysis of the data of table 3. As it follows from these data, the correction procedure of the scale doesn't bring any essential changes into the scale of astrophysical quantities, although the mean values of basic characteristics of the renewed scale differ slightly from the analogous values obtained in the frames of the traditional approach. So, $<T_e>$ value obtained by the use of all stars of the sample (N=108) turns out to make 15992 K for spectral subclass B5, while $<T_e^c>$ value with the use of stars of only (a) group (n=54) makes 15598 K. For the same subclass the quantities $<R>$ and $<R^c>$ are equal to $3.69R_\odot$ and $3.53R_\odot$, and $<M>$ and $<M^c>$ quantities are equal to $5.05M_\odot$ and $4.97M_\odot$, respectively. For the absolute star value its mean values $<M_v>$ and $<M_v^c>$ are equal to $-0^m.98$ and $-1^m.09$, respectively. We see that the differences in the mean values of basic characteristics received by two different ways are really insignificant and their values are within the errors of determination of these mean values. So, the values of differences $<T_e>-<T_e^c>$, $<R>-<R^c>$, $<M>-<M^c>$ and $<M_v>-<M_v^c>$ are equal to 394°K, $0.16R_\odot$, $0.08M_\odot$ and $+0^m.11$, respectively. Comparing these values of differences with those σ_T, σ_R, σ_M and σ_{Mv} values cited for that subclass on pictures 1 and 2, we assure in the validity of our remark.

It should seem that such small distinctions in the mean values obtained by two different ways do not deserve a special attention. However, if we analyze the behavior of g_{dyn} and v_{cr} quantities along spectral sequence from hot stars to cold ones in the renewed scale of astrophysical quantities, then the advantage of the offered approach is easily traced. Let refer to the data of Table 1 where the quantities g_{dyn} and v_{cr} obtained by the renewed scale are presented in columns No. 8 and 9. We see that in spectral range from O5-5.5 to A7 the behavior of the gravity g_{dyn} along spectral sequence from hot stars to cold ones turns out to be habitual. A deviation from such behavior is revealed only near F0 subclass. The change of the velocity v_{cr} along the same sequence is habitual in spectral range from O6-6.5 to A4-5. Interruptions in the behavior of the last is observed at very hot (subclass O5-5.5) and cold (subclasses A7, F0 and F2) stars. It's to the point to underline that the normal behavior of g_{dyn} and v_{cr} quantities at a big expansion along spectral sequence from hot stars to cold ones which we observe, results automatically from the data of the renewed scale.

The following two arguments give us an occasion to assert that the mean values found by the correction procedure are still more correct as compared with those values of the same means determined by traditional method. Let consider the first one. We see that errors of determination of the mean values $<T_e^c>$, $<M^c>$, $<R^c>$ and $<\lg L^c>$ are much less than errors of determination of the mean values $<T_e>$, $<M>$, $<R>$ and $<\lg L>$. So for B1 subclass we received: root-mean-square errors σ_T, σ_M, σ_R and σ_L in determination of $<T_e>$, $<M>$, $<R>$ and $<\lg L>$ values turn out to be equal to ±2595 K, $\pm 2.04M_\odot$, $\pm 1.22R_\odot$ and ±0.30, while root-mean-square errors σ_T^c, σ_M^c, σ_R^c and σ_L^c in determination of $<T_e^c>$, $<M^c>$, $<R^c>$ and $<\lg L^c>$ are equal to ±325 K, $\pm 0.65M_\odot$, $\pm 0.10R_\odot$ and ±0.06, respectively. For B9 subclass we found that: σ_T=±650K, $\sigma_M=\pm 0.32M_\odot$, $\sigma_R=\pm 0.35R_\odot$ and σ_L=±0.17 for quantities $<T_e>$, $<M>$, $<R>$ and $<\lg L>$; and σ_T^c=±160K, $\sigma_M^c=\pm 0.15M_\odot$, $\sigma_R^c=\pm 0.06R_\odot$ and σ_L^c=±0.03

for quantities $<T_e^c>$, $<M^c>$, $<R^c>$ and $<\lg L^c>$, respectively. That is, in both subclasses under consideration the values of errors of determination σ_T, σ_M, σ_R and σ_L turn out to be much more than the values of errors of determination σ_T^c, σ_M^c, σ_R^c and σ_L^c. The second argument is a habitual behavior of dynamic gravity and critical rotation velocity along spectral sequence from hot stars to cold ones inside the renewed scale of astrophysical quantities.

As investigations show, when the sample is thin, it is practically impossible to use the correction procedure. In this case the maximum is faintly observed, and this fact complicates the selection of stars to (a) group. As a result we get the uncertain mean values. Therefore, the only one device required to obtain the reliable mean values of any from basic characteristics is to increase a number of stars in every sample. In our case this remark concerns O5-5.5, A7, F0 and F2 subclasses. Practice shows that when the sample includes 25-30 members, the procedure of selection leads already to the correct results.

Using the data from columns No. 7 and 9 of Table 3, by filling them with polynomial of the first order, we find that the values of a_1 and b_1 are equal to 0.2612 (±0.001) and -0.0260 (±0.003), but using data of columns 8 and 9 we get that a_1= 0.2593 (±0.005) and b_1=-0.0160 (±0.013). We see that the distinctions in values of a_1 and b_1 coefficients of the renewed and not renewed scales are not essential. Then, in order to establish the reasons of the coefficient b_1's appearance in the relation (4), let fulfill the following simple calculations. Let refer to the data of columns No. 8 and 10 of Table 3 and consider the following two examples. Let $<\lg L^c>$ values to be higher and $<M^c>$ values to be lower than the true values of $<\lg L^c>$ and of $<M^c>$, respectively (example No. 1). According to the second example, we suppose that $<\lg L^c>$ values are lower, and $<M^c>$ values are higher the true values of $<\lg L^c>$ and $<M^c>$, respectively. Then, if $<\lg L^c>$ and $<M^c>$ values presented in Table 3 differ from the true ones $<\lg L^c>$ and $<M^c>$ for 10% only, we get a_1=0.2603 and b_1=-0.0734 and a_1=0.2592 and b_1=0.0387 for the first and second examples, respectively. We see that the values of a_1 coefficient remain in both cases invariable, while the values of coefficient b_1 noticeably differ from each other. So, it even changes the sign when transferring from one example to another.

Further, if $<\lg L^c>$ and $<M^c>$ values presented in Table 3 differ from the true ones $<\lg L^c>$ and $<M^c>$ for 5% only, we find that a_1=0.2594 and b_1=-0.0445 and a_1=0.2592 and b_1=0.0102 for the first and second examples, respectively. We see that in this case the situation with a_1 and b_1 coefficients doesn't differ notably from the previous one. But it suffers from evident changes if $<\lg L^c>$ and $<M^c>$ values presented in Table 3 differ from the true ones $<\lg L^c>$ and $<M^c>$, e.g. for 1-2% only. In the last case we have a_1=0.2593 and b_1=-0.0302 and a_1=0.2593 and b_1=-0.0034 for the first and second variants, respectively. We also see that in both examples the quantity b_1 remains negative.

These examples allow to make the following conclusion. In principle, if deviations of quantities $<\lg L^c>$ and $<M^c>$ from the true values $<\lg L^c>$ and $<M^c>$ are not great, then it is not difficult to obtain the elimination of b_1 coefficient in the relation (4) by variation of values of these quantities. However, as it seems to us, the following argument binds us with the necessity of the obligatory presence of the last in mass-luminosity correlation. As calculations show, the quantity a_1 *remains practically invariable even under considerable deviations of the mean values* $<\lg L^c>$ and $<M^c>$ from their true values, while b_1 quantity suffers from essential changes even under small deviations in the mean values under consideration. Then the appearance of coefficient b_1 in the relation (4) is conditioned by not only incorrect knowing of $<\lg L^c>$ and $<M^c>$ values, but also by the presence of different perturbation effects inside the stars. Right their presence brings to the disruption of mass-luminosity correlation and leads to the necessity of introducing the mean star of the given luminosity class. For example, the rotation effect can play the role of one of them. It is known (see, e.g., Sackman and Anand, 1970) that the presence of the angular moment the star has, brings to the deceleration of the nuclear reactions rate and the lowering of its luminosity as compared with non-rotating star of the same mass. It is clear that we should expect even though a weak disruption of mass-luminosity correlation. To confirm this, we can present the fact already established by the observations. So, as investigations show (see, e.g., Krat, 1962), mass-luminosity correlation is not implemented by the secondary components of close binary systems. It is stipulated by the non-standard evolution of stars entering a pair.

6. Conclusion

The offered correction procedure of the scale of astrophysical quantities is not burdensome to our mind. It doesn't change the approach to the scale's construction as a whole, but improve the exactness of finding the mean values of basic characteristics. It is realized by attraction of a big number of stars with the already known values of basic characteristics and their thorough selection. To check the reliability of the obtained mean values it is offered to attract the indicators with their already known behavior. Right the correctness of their behavior in the frames of the constructed scale of astrophysical quantities allows to judge about the reliability of the results.

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