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On the Determination of the Vertices from the Stars of F, G, K, M Types.

In the paper [1]): „On the determination of the vertex from the motus peculiares of stars" the ellipsoidal hypothesis of Schwarzschild has been modified. The motus peculiares of stars being known, the three axis ellipsoidal distribution has been considered according to the modified Maxwellian law:

$$k\, e^{-Au^2 - Bv^2 - Cw^2}\, du\, dv\, dw.$$

To calculate the motus peculiares of the stars of F, G, K and M types, the parallaxes derived by the spectroscopic method by Adams, Joy, Strömberg and Burwell [2]) were used for the stars, whose radial velocities are known. The proper motions were taken from the Boss's Catalogue. The parallactic motion was eliminated, assuming the solar motion 20 km per sec. and the coordinates of solar apex: 270° and +30°. For every star the direction of its motus peculiaris in the aequatorial coordinates and velocity were determined. In this part of the work I am very much indebted to Miss K. Iwaszkiewicz who gave considerable help in carrying out the calculations. The directions of the motus peculiares being considered from a point, the center of the coordinates, the sky was divided into regions and the stars moving in the direction of each region were counted. The following zones and regions were chosen:

I	zone from	—15°	to	+15°	in Dec. and every	30°	in R.A., on the whole	12	regions
II	„ „	+15	„	+45	„ „ „	„	„ „ „ „ „	12	„
III	„ „	—15	„	—45	„ „ „	„	„ „ „ „ „	12	„
IV	„ „	+45	„	+75	„ „ „	60	„ „ „ „ „	6	„
V	„ „	—45	„	—75	„ „ „	„	„ „ „ „ „	6	„
VI	„ „	+75	„	+90	„ „ „	„	„ „ „ „ „	1	„
VII	„ „	—75	„	—90	„ „ „	„	„ „ „ „ „	1	„

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[1]) Bulletin de l'Académie des Sciences de Cracovie. 1916.

[2]) Astrophysical Journal. Vol 53. 1921.

together 50 regions. These areas are unequal; taking the regions of the I zone as unity, the areas of the II and III zone become 1.16 and those of the VI and VII zone 1.26. Therefore the number of stars observed to be moving in the directions of these regions should be augmented in the same ratio.

Let : $Ax^2 + A_1y^2 + A_2z^2 + 2\,Byz + 2\,B_1zx + 2\,B_2xy + H = 0$

where x, y, z are the rectangular aequatorial coordinates, be the equation of the velocity ellipsoid. For the 50 regions we get 50 equations, which we resolve by the method of least squares. When the constants are found, the axis (a, b, c) and their directions can be easily determined.

We begin with the giant stars ($M \leq 3.0$). There are 526 giants of F, G, K, M types with known motus peculiares. This number after the reduction on the regions of the zone I, as unity, increases to 568 stars. Tab. I includes the coordinates of each region and the observed number of stars therein. After determining of the constants of the ellipsoid we calculate the number of stars in each region and build the differences: Observ. - Calcul.; their mean value, without regard to the sign, amounts to 4.1. For the direction of the axes of the velocity - ellipsoid we receive:

a axis : $\alpha = 93^{\circ}\!.4$ $\delta = -\ 9^{\circ}\!.6$
b „ : $\alpha = 18.7$ $\delta = +\ 57.3$
c „ : $\alpha = 177.6$ $\delta = +\ 30.9$

and $\frac{b}{a} = 0.65$, $\frac{c}{a} = 0.53$.

Let us consider now the dwarfs ($M > 3.0$). We have 225 such stars or, after reducing to unit of the region, 240 directions of velocities. By the same method as for the giants we build Tab. II. The direction of the axes of the velocity-ellipsoid are as follows:

a axis : $\alpha = 85^{\circ}\!.6$ $\delta = +\ 23^{\circ}\!.7$
b „ : $\alpha = 321.9$ $\delta = +\ 51\,5$
c „ : $\alpha = 189.3$ $\delta = +\ 28.3$

and $\frac{b}{a} = 0.70$, $\frac{c}{a} = 0.44$.

The direction of the vertex (of the major axis) is rather different for the giant and dwarf stars.

Finally we consider all stars (giants and dwarfs) together. We hawe 760 stars (some stars, omitted in the tables I and II accidently, were added now). After reduction to our unit of the region, we receive 816 directions of velocity. In this case we solve again our 50 equations, the results are in Tab. III. The directions of the axes of the velocity-ellipsoid are:

a axis : $\alpha = 92^{\circ}\!.0 \quad \delta = +\ 0^{\circ}\!.6$
b „ : $\alpha = 1.0 \quad \delta = +\ 61.4$
c „ : $\alpha = 182.3 \quad \delta = +\ 28.5$

and $\frac{b}{a} = 0.68,\ \frac{c}{a} = 0.50.$

These results are in good agreement with those received for giant and dwarf stars separately.

TABLE I.

Zone	Region	Coordinates		Number of stars		O.–C.
		α	δ	Observ.	Calc.	
I	1	20°.6	— 7°.1	5	6	— 1
„	2	46.8	+ 4.0	6	11	— 5
„	3	77.2	+ 3.4	20	25	- 5
„	4	103.0	+ 4.7	16	24	— 8
„	5	132.5	— 3.4	9	12	— 3
„	6	169.0	— 3.6	15	6	+ 9
„	7	196.3	— 2.6	7	6	+ 1
„	8	220.3	+ 4.5	8	9	— 1
„	9	256.9	— 0.8	39	25	+ 14
„	10	283.8	+ 2.8	33	28	+ 5
„	11	308.6	+ 6.4	11	14	— 3
„	12	343.5	0.0	5	6	— 1
II	13	15.3	+ 26.0	8	7	+ 1
„	14	49.0	30.0	10	11	— 1
„	15	76.6	30.1	19	15	+ 4
„	16	102.9	28.8	17	8	+ 9
„	17	133.7	24.3	9	8	+ 1
„	18	154.8	25.2	2	5	— 3
„	19	198.3	31.2	5	5	0
„	20	230.6	31.1	9	9	0
„	21	256.9	26.7	35	20	+ 15
„	22	283.9	25.7	44	27	+ 17
„	23	311.2	30.4	14	15	— 1
„	24	349.7	26.0	8	8	0
III	25	23.5	— 36.5	4	5	— 1
„	26	34.2	— 30.8	4	6	— 2
„	27	73.1	— 26.8	9	18	— 9
„	28	104.9	— 23.5	8	27	— 19
„	29	133.3	— 28.7	4	15	— 11
„	30	166.9	— 28.6	13	8	+ 5
„	31	200.0	— 28.5	10	8	+ 2
„	32	222.7	— 34.7	10	10	0
„	33	256.7	— 29.1	17	16	+ 1
„	34	283.0	— 27.0	15	14	+ 1
„	35	310.7	— 28.0	8	8	0
„	36	342.2	— 27.7	2	5	— 3
IV	37	40.2	+ 67.7	3	9	— 6
„	38	99.1	54.8	7	9	— 2
„	39	144.3	58.3	9	6	+ 3
„	40	203.0	62.4	8	6	+ 2
„	41	270.1	54.4	18	13	+ 5
„	42	328.3	62.6	7	6	+ 1
V	43	26.4	— 53.4	2	6	— 4
„	44	85.5	— 53.6	9	13	— 4
„	45	148.2	— 60.3	7	11	— 4
„	46	201.6	— 56.8	8	9	— 1
„	47	269.6	— 54.0	12	9	+ 3
„	48	317.6	— 60.8	2	6	— 4
VI	49	46.9	+ 87.2	9	8	+ 1
VII	50	326.6	— 84.8	9	7	+ 2

TABLE II

Zone	Region	Coordinates		Number of stars		O.—C.
		α	δ	Observ.	Calc.	
		°	°			
I	1	11.8	— 2.5	2	2	0
„	2	53.8	— 5.4	2	3	— 1
„	3	72.4	+ 1.5	8	7	+ 1
„	4	101.3	+ 2.1	22	11	+ 11
„	5	137.1	— 1.7	4	4	0
„	6	157.9	— 9.9	3	2	+ 1
„	7	193.4	+ 4.8	1	2	— 1
„	8	225.0	0.0	0	3	— 3
„	9	257.3	+ 1.1	3	8	— 5
„	10	285.6	— 6.2	7	11	— 4
„	11	306.5	— 0.6	2	5	— 3
„	12	351.5	+ 3.0	2	2	0
II	13	15.0	+30.0	0	3	— 3
„	14	44.8	17.3	2	4	— 2
„	15	76.4	25.4	16	14	+ 2
„	16	103.9	27.4	18	10	+ 8
„	17	129.5	33.5	6	3	+ 3
„	18	168.2	25.3	1	2	— 1
„	19	180.6	44.8	1	1	0
„	20	235.1	29.2	1	2	— 1
„	21	248.7	35.6	3	3	0
„	22	286.0	32.5	3	6	— 3
„	23	300.5	39.2	1	5	— 4
„	24	345.0	30.0	0	3	— 3
III	25	9.2	—36.4	2	1	+ 1
„	26	45.0	—30.0	0	2	— 2
„	27	78.9	—32.7	6	4	+ 2
„	28	104.0	—26.0	9	6	+ 3
„	29	132.1	—30.1	8	5	+ 3
„	30	168.5	—31.4	5	3	+ 2
„	31	193.2	—35.5	7	4	+ 3
„	32	227.8	—31.4	8	7	+ 1
„	33	258.9	—27.5	10	14	— 4
„	34	284.6	—29.3	7	9	— 2
„	35	317.8	—38.4	2	2	0
„	36	344.3	—28.3	2	2	0
IV	37	57.2	+60.2	1	8	— 7
„	38	94.0	56.6	7	7	0
„	39	133.7	63.2	2	3	— 1
„	40	216.9	69.3	2	2	0
„	41	275.2	65.6	4	3	+ 1
„	42	351.4	59.6	2	5	— 3
V	43	27.6	—51.5	2	2	0
„	44	99.7	—57.0	3	4	— 1
„	45	142.5	—65.7	7	5	+ 2
„	46	221.4	—58.9	10	7	+ 3
„	47	274.0	—52.6	14	8	+ 6
„	48	324.9	—69.4	5	3	+ 2
VI	49	90.0	+84.7	3	4	— 1
VII	50	189.8	—85.3	4	4	0

TABLE III.

Zone	Region	Coordinates		Number of stars		O.—C.
		α	δ	Observ.	Calc.	
		°	°			
I	1	18.1	— 5.8	7	7	0
„	2	48.5	+ 1.6	8	14	— 6
„	3	75.8	+ 2.9	28	35	— 7
„	4	102.0	+ 3.2	38	40	— 2
„	5	134.0	— 2.8	13	15	— 2
„	6	167.2	— 4.7	18	8	+ 10
„	7	196.0	— 1.7	8	8	0
„	8	220.3	+ 4.5	8	10	— 2
„	9	259.2	— 0.8	44	38	+ 6
„	10	284.1	+ 1.2	40	41	— 1
„	11	308.2	+ 5.3	13	19	— 6
„	12	344.7	+ 1.6	8	8	0
II	13	15.3	+ 26.0	8	10	— 2
„	14	48.2	27.7	13	18	— 5
„	15	76.5	27.9	35	31	+ 4
„	16	103.4	28.4	36	24	+ 12
„	17	132.1	27.8	15	12	+ 3
„	18	159.3	25.2	3	7	— 4
„	19	194.7	33.9	6	6	0
„	20	231.1	30.9	10	10	0
„	21	256.2	27.5	38	21	+ 17
„	22	283.9	26.0	48	31	+ 17
„	23	310.3	31.0	15	20	— 5
„	24	349.0	24.9	9	10	— 1
III	25	17.8	— 36.4	6	6	0
„	26	34.2	— 30.8	3	7	— 4
„	27	75.3	— 29.0	14	18	— 4
„	28	103.5	— 23.3	18	33	— 15
„	29	132.4	— 29.7	12	19	— 7
„	30	167.3	— 29.3	17	11	+ 6
„	31	197.2	— 31.3	17	11	+ 6
„	32	225.0	— 33.2	18	17	+ 1
„	33	257.5	— 28.5	28	31	— 3
„	34	283.5	— 27.7	22	24	— 2
„	35	312.3	— 30.3	10	11	— 1
„	36	343.2	— 28.0	5	6	— 1
IV	37	47.0	+ 59.4	6	16	— 10
„	38	94.4	56.1	15	15	0
„	39	142.4	59.2	11	8	+ 3
„	40	205.8	61.8	10	8	+ 2
„	41	266.4	56.0	23	18	+ 5
„	42	332,8	60.4	10	15	— 5
V	43	27.0	— 52.4	4	7	— 3
„	44	89.0	— 54.5	12	14	— 2
„	45	136.7	— 58.0	14	16	— 2
„	46	212.6	— 58.0	18	15	+ 3
„	47	272.0	— 53.3	26	16	+ 10
„	48	322.8	— 66.9	7	9	— 2
VI	49	53.7	+ 89.5	10	11	— 1
VII	50	117.4	— 89.0	11	11	0

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WŁ. DZIEWULSKI.

On the Systematic Motions of Stars.

Second paper.

In the preceding paper: „On the determination of the vertices from the stars of F, G, K and M types“ the direction of the vertices of the movement of stars was determined. We consider now the giant stars alone. This corresponds to the first solution (table I) of the cited paper. We return now to the problem, which was considered in the first paper „On the systematic motions of stars“ [1]), namely that of the change of direction of the line vertex-antivertex for stars of different distances.

For the giant stars of F, G, K and M types the direction of the vertex is calculated to be:

$$\alpha = 93\overset{0}{.}4 \quad \delta = -\,9\overset{0}{.}6 \text{ (in galactic coord. } l = 185\overset{0}{.}5 \quad b = -\,10\overset{0}{.}3\text{)}.$$

We put through the centre of the sphere, or the point of observation a plane perpendicular to the line of vertex-antivertex We divide our system of stars into two groups: one part will be found on the vertex side of the sphere, the other one — on the antivertex side. For both groups we determine the direction of the vertices according to the hypothesis of the three-axis ellipsoid [2]). We have 535 stars (9 stars were added to the number of 526 stars, considered in the former problem), namely 242 stars on the side of the vertex and 293 on the opposite side. Reduced to the region of the zone I as unity, there are 259 and 317 directions in the two groups. Resolving our system of 50 equations for each group, we receive for the stars, situated on the vertex side, the following coordinates of the direction of the vertex:

$$\alpha = 94\overset{0}{.}0 \qquad \delta = -\,6\overset{0}{.}3$$

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[1]) Bulletin de l'Observatoire astronomique de Wilno. Nr. 6. 1925.

[2]) Bulletin de l'Académie des Sciences de Cracovie. 1916.

whereas for the stars on the side of the antivertex the following coordinates of the direction of the vertex are:

$$\alpha = 94\overset{0}{.}9 \qquad \delta = -\ 12\overset{0}{.}2$$

Taking for the galactic pole the coordinates of Pickering: $\alpha = 190^0$, $\delta = +28^0$, we get for these two directions of the vertices (for the two groups of stars) the galactic coordinates:

$$l = 182\overset{0}{.}7 \qquad b = -\ 8\overset{0}{.}1$$

and $$l = 188\overset{0}{.}6 \qquad b = -\ 10\overset{0}{.}0$$

respectively.

In this manner we receive a change of the longitude of the movement of stars. This result is in agreement with the analogous results, formerly arrived at for the stars with known peculiar movements.

It is known, that the vertices are lying near to the galactic plane. Our solution gives for the vertex the galactic coordinates: $l = 185^\circ\!.5$, $b = -10^\circ\!.3$. For the ascending node (towards which the x-axis is directed) of the galactic plane we have $\alpha = 290^0$ ($l = 0^0$); our antivertex ($l = 5^\circ\!.5$, $b = +10^\circ\!.3$) is lying near to this point.

The galactic plane was taken as plane of reference, the rectangular galactic coordinates and the galactic components of the total peculiar velocity were reckoned. During these calculations, made with Miss Iwaszkiewicz's valuable help, Mr Balanowsky has published his „Catalogue of the space-velocities of 1488 stars“ [1]) and I could make use of his galactic rectangular coordinates. The components of the total peculiar velocity are taken into account according to our calculations.

Let us consider now the distribution of the velocities of the stars relatively to the galactic plane. The descending and ascending nodes of the galactic plane lying near to the vertex and antivertex, it is interesting to see, how the velocities are distributed with reference to the y-axis of the galactic plane (the positive y-axis is directed to the point of galactic longitude $= +90^0$). The coordinates are expressed in parsecs. We use now all the stars of F, G, K, M types with except of those, whose peculiar velocities exceed 80 km per sec. We add also the peculiar velocities of the A stars, whose parallaxes and radial velocities are known.

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[1]) Bulletin de l'Institut Astronomique. Nr. 11. Leningrad. 1925.

[2]) Astrophysical Journal. Vol. 56. 1922.

We receive the following table:

Table I

y	Number of stars	Mean velocity km/sec
$y \leq 5$	234	27.4
$5 < y \leq 40$	273	25.2
$40 < y$	241	23 2

Dividing the stars in a greater number of groups we find:

y	Number of stars	Mean velocity km/sec
$y \leq 0$	180	27.2
$0 < y \leq 15$	146	27.0
$15 < y \leq 35$	160	24.6
$35 < y \leq 65$	139	23.7
$65 < y$	123	22.9
$y \leq -5$	147	25.9
$-5 < y \leq 10$	139	29.6
$10 < y \leq 20$	85	25.2
$20 < y \leq 40$	136	23 7
$40 < y \leq 65$	118	23.4
$65 < y$	123	22 9

In the last groups the distribution has lost its regular character.

Returning to our first distribution of the stars into 3 groups and taking into account the x-coordinate, we consider two groups relating to the x-axis, namely positive and negative values of the x-coordinate. We get:

Table II-a.

y	Number of stars and mean velocities					
	$x \leq 0$		$x > 0$		All stars	
$y \leq 5$	106	28.2	128	26.7	234	27.4
$5 < y \leq 40$	130	25.3	143	25.1	273	25.2
$40 < y$	131	24.1	110	22.0	241	23.2

It seems, that the velocities on the negative side of the x-axis are greater than those on the positive one. Between the giant M-stars we have a rather large number of such stars, whose peculiar velocities are great. Therefore we omit from table II-a all stars of type M (68). We get:

Table II b.

y	Number of stars and mean velocities					
	$x \leq 0$		$x > 0$		All stars	
$y \leq 5$	96	27.0	116	26.6	212	26.8
$5 < y \leq 40$	122	24.8	134	25.2	256	25.0
$40 < y$	115	23.3	97	20.9	212	22.2

The results of this table are analogous to those of the table II-a, only the velocities are smaller.

Let us examine at last those stars, for which the directions of the velocity-vectors are distributed near to the vertex and the antivertex; the velocity-vectors were choosed, which are distant from the vertex or antivertex less than 45°. Table III-a gives the distribution of the velocities for the vectors, directed near to the antivertex.

Table III-a.

y	Number of stars	Mean velocity km/sec
$y \leq 5$	70	29.3
$5 < y \leq 40$	79	29.9
$40 < y$	102	22.4

As we have only 14 stars of the M type and these stars have exceptionally great values, we exclude them and receive:

Table III-b.

y	Number of stars	Mean velocity km/sec
$y \leq 5$	67	29.3
$5 < y \leq 40$	76	29.3
$40 < y$	94	21.9

In the same way we consider the stars moving in the direction near to the vertex. Omitting the few stars, for which $y > 40$, we receive the following table IV:

Table IV.

y	Number of stars	Mean velocity km/sec	Without the M stars	
			Number of stars	Mean velocity km/sec
$y \leq 5$	46	28.1	42	27.8
$5 < y \leq 40$	59	22.6	57	22 2

The results of the tables III and IV confirm the character of the distribution as shown by the tables I and II. Obviously in the distribution of the velocity-vectors along the y-axis (which is perpendicular by approximate to the direction of the line vertex-antivertex in the galactic plane) an increase of average velocities of stars takes place.

We have formerly considered two groups of stars near to the vertex and antivertex and we have found the change of the longitude of the vertex in the movement of stars. These results were based on the modified Schwarzschild's hypothesis and are not in accordance with the present ones.

Wilno, 1926. VI. 27.

B J C

It seems, that the velocities on the negative side of the y-axis are greater than those on the positive side. Between the giant M stars we have a rather large number of such stars whose peculiar velocities are great. Therefore we omit from Table II a all stars of type M (68). We get:

Table II b.

Number of stars and mean velocities

y	All stars	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The results of this table are analogous [illegible] only the velocities [illegible] of the velocity-vectors are distributed near to the vertex [illegible]

y	Number of stars	Mean velocity km/sec
y < -5	70	29.3
-5 < y < 40	59	29.9
40 < y	[illegible]	22.4

As we have only 14 stars of [illegible] type and these stars have exceptionally great values, we exclude them and receive:

Table III b

y	Number of stars	Mean velocity km/sec
y < -5	67	29.3
-5 < y < 40	76	29.5
40 < y	94	31.9

WŁ. DZIEWULSKI.

On the variable star U Monocerotis.

I observed in Cracow the variable star U Monocerotis since December 13th 1912 until April 6th 1914. I made on the whole 46 observations with a four inches short focus refractor. For reference I used the following stars (the magnitudes are taken from the Henry Draper Catalogue H. A. Vol. 93)

star	H. A.	steps
— 11° 2106	$5^{m}52$	32 2
— 10 2067	6.00	23.8
— 8 1964	6.02	18.8
— 9 2069	6.62	11.7
— 9 2043	6.86	6.2
— 9 2086	6.97	7.2
— 9 2097	7.51	0.0

As starting point I took the elements for maximum:

$$\text{J. D. } 2408872.0+46.13 \text{ E}$$

The number of observations in the case of this variable is too small that we could precisely calculate the moment of maximum and minimum and that we could observe the oscillations of maximum or minimum, indicated by Chandler. The observations, expressed in units of my scale, were grouped according to the period; every group contained six observations and intermediate groups were formed. The observations got the following mean values:

d.	st.	d.	st
0.32	24.0	26.28	9.8
3.44	24.3	28.11	11.8
4.99	23.5	31.41	16.5
7.46	24.1	34.20	18.4
10.11	22.4	36.80	21.2
14 00	17.6	39.18	24.2
18.80	13.0	41.98	24.2
22.20	10 6		

The mean error of each observation amounts to ± 3.2, i. e. ± $0^{m}19$ in the Harvard scale.

As the mean moments of the maximum and the minimum we have received:

Max. = J.D. 2420034.8
Min. = J.D. 2420014.8

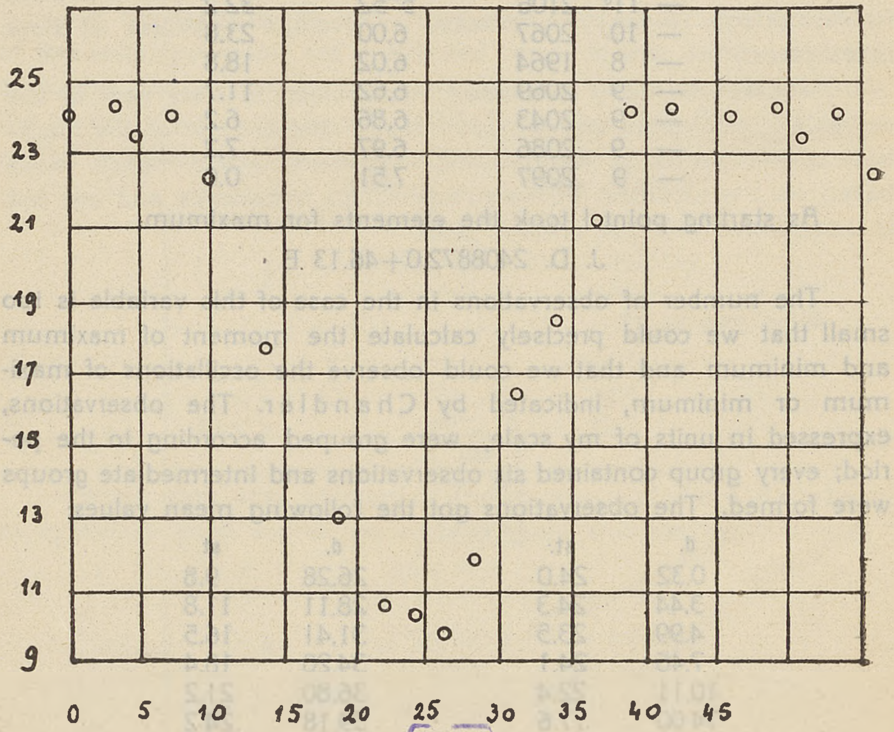
Comparing the observed moments with the calculated:

Max. = J.D. 2420035.5
Min. = J.D. 2420017.1

we receive as corrections : observ. — calc.

for the moment of the maximum : -- 0.7
" " " " " minimum : — 2.3

The curve represents the alteration of brightness of the star. In my scale the brightness oscillates between 24.6 and 9.7, which corresponds to 5.88 and 6.77 of the Harvard scale. For the difference between maximum and minimum we receive M—m = 18.8.



Wilno, 1926. IX, 17.