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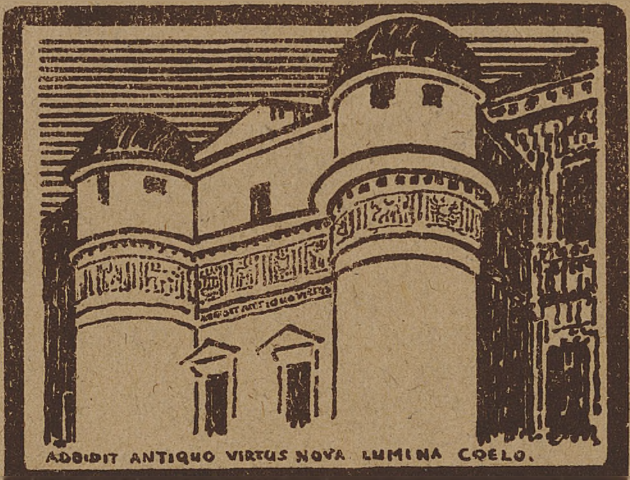
I. ASTRONOMIE.

№ 9.


ADDIDIT ANTIQUO VIRTUS NOVA LUMINA COELO.

BIULETYN OBSERWATORJUM ASTRONOMICZNEGO W WILNIE.

ROK 1928

M.D.

ODBITO W ZAKŁ. LITOGRAFICZNYM P. F. JAN COTTY. WARSZAWA KAPUCYŃSKA 7.

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Drük. „ZNICZ" Wilno.

WILHELMINA IWANOWSKA.

On the Determination of the Solar Motion according to Bravais's Method.

The Data of Observations.

In this investigation stars with known spectroscopic parallaxes, radial velocities and proper motions were gathered from the following sources: I. Publications de l'Institut Astrophysique de Russie, Vol. III fasc. II, Moscou 1926 (1471 stars with given components of the velocities of stars relative to the Sun). II. The spectroscopic parallaxes were collected from:. 1) Monthly Notices, Vol. LXXXVII, 5 and Vol. LXXXVIII,3; 2) Astrophysical Journal, Vol. LVII and LXIV; 3) Osservazioni e memorie del R. Osservatorio astr. di Arcetri, Nr. 42. — III. The radial velocities were collected from the Astrophysica-Journal, Vol. LVII, LXIV and the proper motions from Boss's Preliminary General Catalogue. From these data (II, III) the components of the velocities of 350 stars relative to the Sun were reckoned. On the whole 1821 stars were used to determine the solar motion.

The Method.

The well known method of Bravais was applied to determine the solar motion. The following problems were considered: the stars were classified: 1) according to their spectral types, 2) according to absolute magnitudes and 3) according to peculiar velocities. In every case the solar motion was calculated. For resolving the Bravais's equations the graphical method was applied: in this way the central values instead of the mean ones could be received. This method diminishes the influence of intrinsic stellar motions and is therefore of advantage. Only in the case, when groups were formed according to the peculiar velocities of stars, the mean values were computed; in this case the graphical method would be uncertain and hardly legitimate.

The equations of B r a v a i s contain the masses of stars. The investigations of S e a r e s and E d d i n g t o n permit to determine these masses, and there are some authors, who had introduced the masses in the B r a v a i s's equations. In the present investigation the masses were not taken into consideration, i. e. the solar motion was referred to the geometrical centre of the stellar system. It seems obvious that the graphical method of resolving the B r a v a is's equations leads to similar results as the calculation allowing for the masses. It is known that the stars with small masses have generally large motions. Accounting for the masses we give small weights to the stars with large motions. The graphical method eliminates also the influence of these stars. This question is of little importance, if the stars are enclosed in narrow limits in regard to the spectral types and to the absolute magnitudes.

The Results.

1. Solar motion calculated from different spectral types of stars.

The stars are classified according to their spectra and the solar motion is investigated out of the motion of stars of different spectral types. Table I gives the aequatorial coordinates of the solar apex (A, D) and the velocity of the solar motion (V) calculated by means of giant and dwarf stars of different spectral types separately and then together for all stars of each type and for all stars.

TABLE I.

Type	Giant stars				Dwarf stars				All stars (giant and dwarf)			
	Number of stars	A	D	V (km/sec)	Number of stars	A	D	V (km/sec)	Number of stars	A	D	V (km/sec)
1	2	3	4	5	6	7	8	9	10	11	12	13
B	357	279°.2	27°.0	17.6	—	—	—	—	357	279°.2	27°0	17 6
A	285	263 0	28.2	11.2	—	—	—	—	286	263.0	28.2	11.2
F	110	274.5	24 3	12.7	146	275°8	28°.1	29.1	256	275.5	24.1	20 6
G	172	270.0	29.4	13.7	150	282.4	25.5	40.6	322	278.1	26.3	21 4
K	322	283.2	40.3	12.7	130	280.8	29.3	40.9	452	280.9	35.2	16 9
M	119	283.3	40.5	14.3	—	—	—	—	123	283.3	40.5	14.3
All	1366	275.6	29.7	14.1	426	280.4	27.8	35.6	1796	276.2	28.0	16.6

Table I shows that the giant stars of the types A, F, G, K, M give small values (especially — A-type stars) for the velocity of the Sun. The B-stars lead to the value 17.6 km/sec, differing considerably from that given by stars of other types. It must be noted that from the stars of the B- and A-types 25 stars of Taurus-, Perseus-, Scorpio-Centaurus- and Ursa Major- streams were omitted. As for the direction of the solar apex it may be remarked that from the „later" types a larger declination follows than from the „earlier" ones; this phenomenon is well known. The columns 7 and 8 show that the dwarf stars exhibit no differences in the values of the coordinates of the solar apex; the resulting velocity of the Sun is much greater than in the case of giant stars and increases with the spectral type (column 9). This phenomenon depends rather on the absolute magnitude of stars than on their spectral type. Among the dwarf stars prevail stars of the absolute magnitude 3—4 in the spectral type F and 4 — 6 in the spectral type G, the stars of the K-type are still fainter; such a distribution of the absolute magnitudes among different spectral types is in accordance with the well known diagram of Russell. As in our table appear the dwarf stars only in the spectral types F, G and K (the M-type is represented by 4 stars only), therefore the column, containing the determination of the solar motion for giant and dwarf stars for different spectral types, is of little interest. The results depend on the proportion of giant and dwarf stars, belonging to different spectral groups.

2. Solar motion and absolute magnitudes.

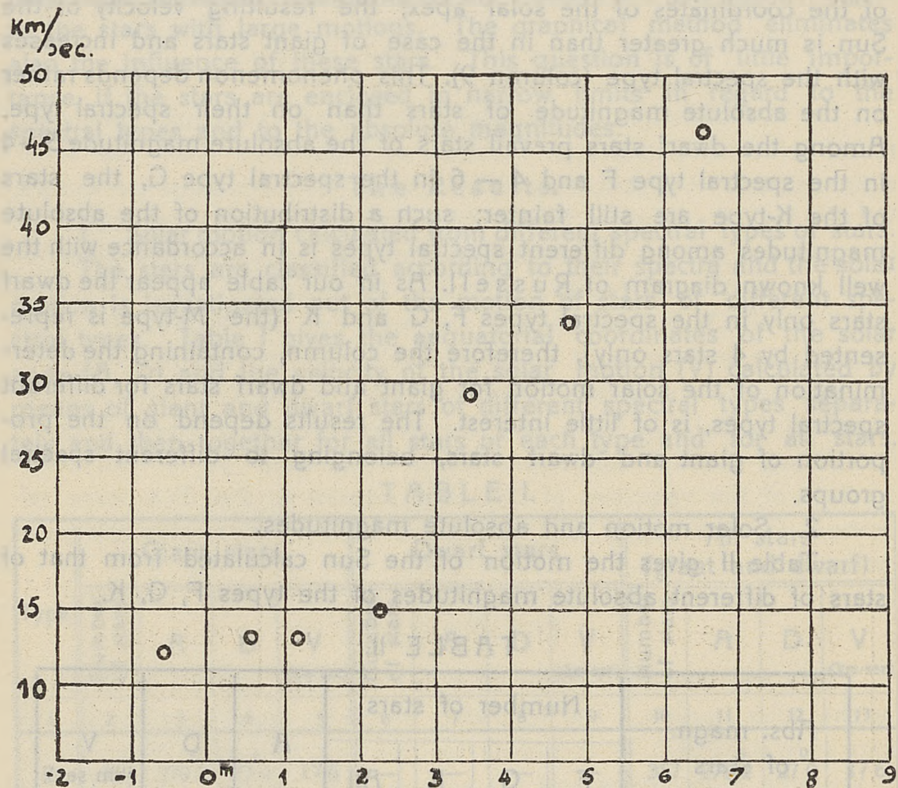
Table II gives the motion of the Sun calculated from that of stars of different absolute magnitudes of the types F, G, K.

TABLE II.

Abs. magn. of stars	Number of stars				A	D	V (km/sec)
	F	G	K	All			
..... + 0.3	30	80	29	139	262.4°	36.3°	12.1
+ 0.4.. + 0.7	5	27	138	170	279 4	37.8	13.2
+ 0.8.. + 1.5	13	40	104	157	285.9	27.2	13.1
+ 1.6.. + 2.9	62	31	39	132	282.0	33.9	15.0
+ 3.0.. + 3.9	120	16	7	143	275.5	22.9	29 2
+ 4.0.. + 5 5	39	91	9	139	280.3	30 9	33.9
+ 5.6......	--	42	108	150	283.5	24.5	46.2

It is interesting to notice that the solar motion depends on the absolute magnitude of stars, the velocity of the solar motion increasing with decreasing brightness of stars. This dependance seems to be not continuous; for from stars of the absolute brightness 3^m upwards the speed of the solar motion increases rapidly. It follows from the diagram (fig. 1) that the law of the increase of the velocity of the Sun might be represented by one curve, one part of which, viz. that corresponding to dwarf stars has been shifted towards larger velocities.

Fig. 1.



3. Solar motion and peculiar velocities of stars.

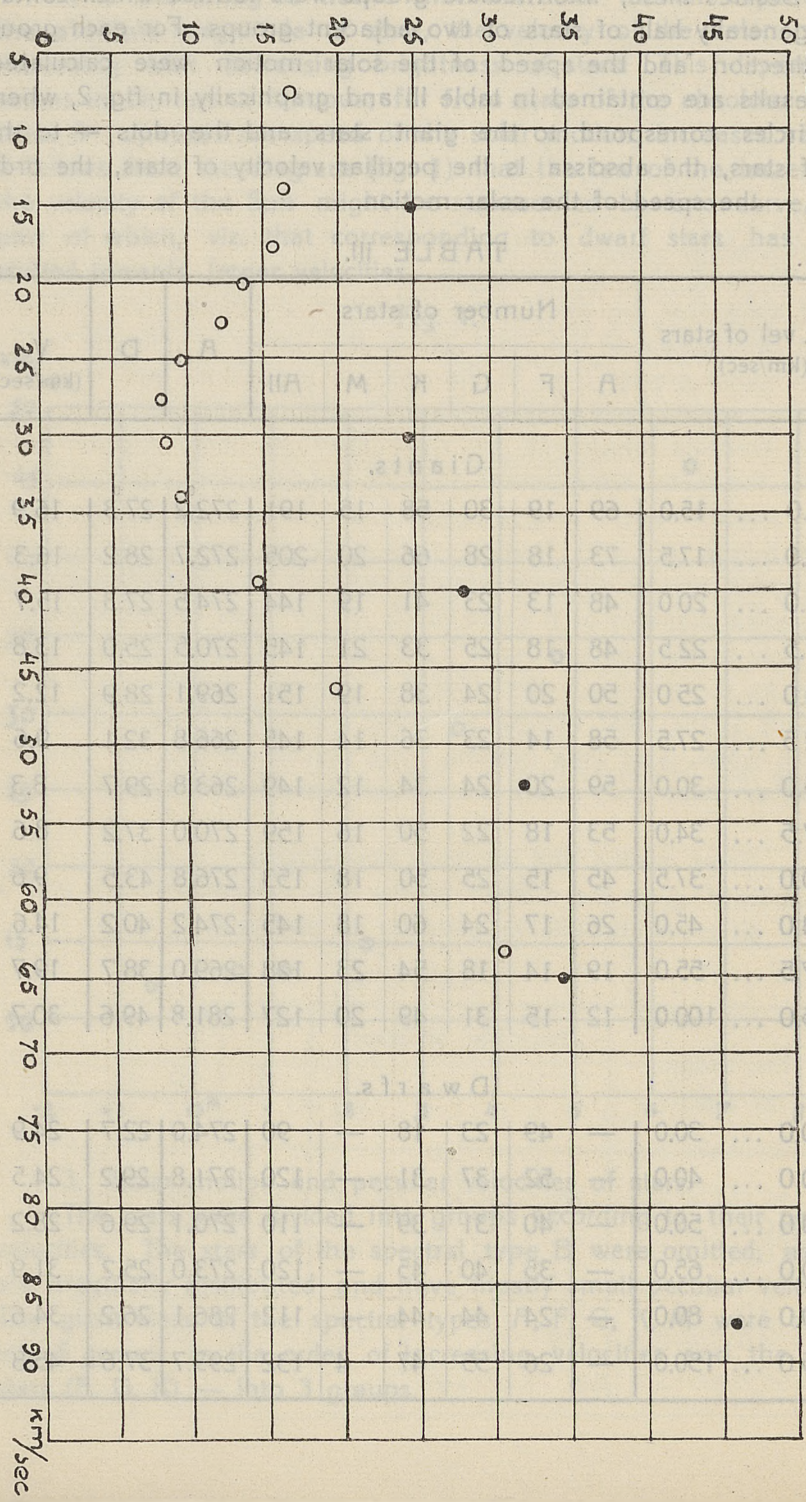
The stars were divided into groups according to their peculiar velocities. The stars of the spectral type B were omitted, as they are irregularly distributed and have mostly small peculiar velocities. The giant stars of the spectral types A, F, G, K, M were divided into 6 groups in the order of increasing velocities and the dwarf stars (F, G, K) — into 3 groups.

Besides these, intermediate groups were formed which contained generally half of stars of two adjacent groups. For each group the direction and the speed of the solar motion were calculated; the results are contained in table III and graphically in fig. 2, where the circles correspond to the giant stars and the dots — to the dwarf stars, the abscissa is the peculiar velocity of stars, the ordinate — the speed of the solar motion.

TABLE III.

Pec. vel of stars (km/sec)	Number of stars						A	D	V (km/sec)
	A	F	G	K	M	All			
Giants.									
0.0 ... 15.0	69	19	30	58	15	191	272°.2	27°.3	16.9
10.0 ... 17.5	73	18	28	66	20	205	272.7	28.2	16.3
15.0 ... 20 0	48	13	23	41	19	144	274 5	27.3	15.7
17.5 . . 22.5	48	18	25	33	21	145	270.5	25.0	13.8
20.0 ... 25 0	50	20	24	38	19	151	269.1	28.9	12.2
22 5 ... 27.5	58	14	23	36	14	145	266.8	32.1	9.6
25.0 ... 30.0	59	20	24	34	12	149	263.8	29.7	8.3
27.5 ... 34.0	53	18	22	50	16	159	270 0	37.2	8.6
30.0 ... 37.5	45	15	25	50	18	153	276.8	43.5	9.6
34.0 ... 45.0	26	17	24	60	18	145	274 2	40.2	14.6
37.5 ... 55.0	19	14	18	54	23	128	269.0	38.7	19.7
45.0 ... 100.0	12	15	31	49	20	127	281.8	49.6	30.7
Dwarfs.									
0.0 ... 30.0	—	49	23	18	—	90	274.0	22.7	24.9
20.0 ... 40.0	—	52	37	31	—	120	271.8	29.2	24.5
30.0 ... 50.0	—	40	31	39	—	110	270.1	29.6	28.2
40.0 ... 65.0	—	35	40	45	—	120	273.0	25.2	31.9
50.0 ... 80.0	—	24	44	44	—	112	286.1	26.2	34 6
65 0 ... 150.0	—	26	55	47	4	132	299.7	37.6	45.8

Fig. 2.



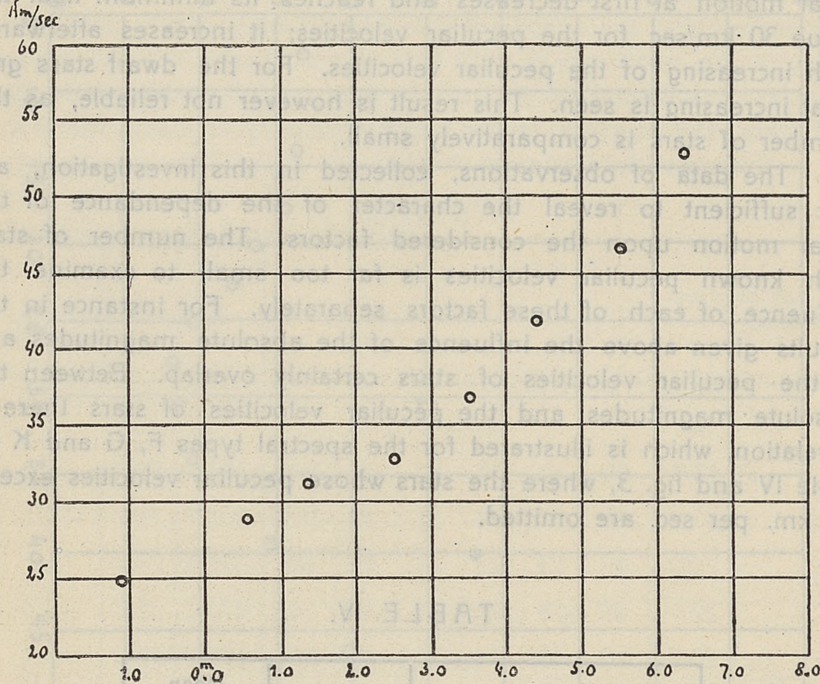
The diagram shows that for the giant stars the speed of the solar motion at first decreases and reaches its minimum near the value 30 km/sec for the peculiar velocities; it increases afterwards with increasing of the peculiar velocities. For the dwarf stars gradual increasing is seen. This result is however not reliable, as the number of stars is comparatively small.

The data of observations, collected in this investigation, are not sufficient to reveal the character of the dependance of the solar motion upon the considered factors The number of stars with known peculiar velocities is far too small to examine the influence of each of these factors separately. For instance in the results given above the influence of the absolute magnitudes and of the peculiar velocities of stars certainly overlap. Between the absolute magnitudes and the peculiar velocities of stars there is a relation, which is illustrated for the spectral types F, G and K by table IV and fig. 3, where the stars whose peculiar velocities exceed 80 km. per sec. are omitted.

TABLE IV.

Absolute magnitude of stars	Number of stars	Mean peculiar velocity of stars (km/sec)
...... 0.0	74	24.9
0.0 ... + 1.0	277	28.9
+ 1.0 ... + 2 0	138	31.1
+ 2.0 ... + 3.0	74	32 7
+ 3.0 ... + 4.0	115	36 6
+ 4.0 ... + 5.0	72	41.6
+ 5.0 ... + 6 0	61	46 4
+ 6.0 ... + 7.0	58	52.7

Fig. 3.



Wilno, 1928. XI. 18.

WŁ. DZIEWULSKI.

WŁ. DZIEWULSKI.

On the Systematic Motions of Stars.

Third paper.

In the second paper on this subject I have considered the distribution of the velocities of 748 stars relatively to the galactic plane. As now many more stars, for which the parallaxes, the radial velocities and the proper motions are known, have been collected by Miss W. Iwanowska, the considerations, concerning the distribution of the velocities of stars, may be repeated. Miss W. Iwanowska has calculated the space- or peculiar-velocities, assuming for the speed of the solar motion 20 km per sec. and for the direction: $\alpha = 270^0$, $\delta = +30^0$.

The galactic plane was taken for the plane of reference; the coordinates of the pole of the galactic plane were assumed: $\alpha = 191^0.1$, $\delta = +26^0.8$. The rectangular galactic coordinates and the galactic components of the total peculiar velocity were reckoned. For the galactic coordinates use was made of the values calculated by Mr. Balanowsky[1]). For the greater part the tables for every 20^m of Rectascension and 5^0 of Declination were used, which Mrs J. Jantzen has calculated and kindly put at my disposal.

Let us consider 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, we suppose for this moment to coincide. It is interesting to see, how the velocities are distributed with reference to the y-axis of the galactic plane (the positive x-axis is directed to the ascending node of the galactic plane, the positive y-axis is then directed to the point of galactic longitude $= 6^h$). The coordinates are expressed in parsecs.

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[1]) Bulletin de l'Institut Astronomique. № 11. Leningrad. 1925.

We use now all the stars of B, A, F, G, K, M types with the exception of those, whose peculiar velocities exceed 80 km per second. Dividing the stars in three groups with reference to the y-axis, we receive the following table.

Table 1-a.

y	Number of stars	Mean velocity km/sec
$y \leq 10$	768	32.3
$10 < y \leq 45$	556	28.5
$45 < y$	509	24.7

It is known that the dwarf stars have upon the average larger velocities than the giant stars. On the other hand the majority of dwarf stars, for which the peculiar velocities could be calculated, are situated near to our Sun, i. e. the absolute values of „y“ are small. The dwarf stars are therefore distributed unsymmetrically and can influence our results. Table I-a contains 209, 104 and 8 dwarf stars in successive groups. For the reason just mentioned the stars of the absolute magnitude more than $3^m.0$ are further left out of consideration. We get table I-b including giant stars only.

Table I-b.

y	Number of stars	Mean velocity km/sec
$y \leq 10$	559	28.5
$10 < y \leq 45$	452	25.0
$45 < y$	501	24.2

Omitting the stars, whose peculiar velocities exceed 60 km per second, we arrive at table I-c, which is analogous to the table I-b but the mean velocities are smaller.

Table I-c.

y	Number of stars	Mean velocity km/sec
y ≤ 10	533	24.6
10 < y ≤ 45	437	23.6
45 < y	485	22.7

These results confirm those arrived at in the second paper. They show that the distribution of the velocities of the stars depends on the distance from the x-axis (parallel to the line vertex-antivertex and passing through our Sun).

We take into consideration only the giant stars. In order to get a homogenous material for the investigation of the distribution of the velocities a separate treatment of different spectral types is of importance. Forming two groups of stars according to the values of y-coordinate, we consider all the 6 types separately and then three groups (B-A, F-G, K-M), as the numbers of stars in separate groups are relatively small.

Table II-a.

Type	y ≤ 25		y > 25	
	Number of stars	Mean vel. km/sec	Number of stars	Mean vel. km/sec
B	142	17.0	224	17.0
A	208	23.4	102	25.0
F	73	30.7	52	24.9
G	142	30.8	124	28 6
K	163	31.4	159	28 2
M	61	31.1	62	28.1
B-A	350	20.8	326	19.5
F-G	215	30.7	176	27.5
K-M	224	31.3	221	28.2
All stars	789	26.5	723	24.1

As regards the separate types only the stars of the A-type do not show the generally observed relationship between velocity and distribution along the y-axis. Omitting again the stars, whose peculiar velocities exceed 60 km per sec, we receive:

Table II-b.

Type	y ≤ 25		y > 25	
	Number of stars	Mean vel. km/sec	Number of stars	Mean vel. km/sec
B	142	17.0	222	16.5
A	206	22 9	101	24.6
F	69	28.3	51	24.1
G	130	27.0	114	25.2
K	150	28.2	152	26.5
M	56	27.8	62	28.1
B-A	348	20.5	323	19.1
F-G	199	27.5	165	24.9
K-M	206	28.1	214	26.9
All stars	753	24.4	702	22.8

These results are analogous to those given in table II-a.

At last let us examine the stars, for which the directions of the velocity-vectors are distributed near to the vertex and antivertex; the velocity-vectors were chosen, which are distant from the vertex or antivertex less than 45^0. We omit again all the stars, whose peculiar velocities exceed 80 km per second. The results are given in the following table:

Table III.

Type	Near to the antivertex				Near to the vertex				Near to the anti-vertex and vertex			
	y ≤ 25		y > 25		y ≤ 25		y > 25		y ≤ 25		y > 25	
	Number of stars	Mean vel. km/sec	Number of stars	Mean vel. km/sec	Number of stars	Mean vel. km/sec	Number of stars	Mean vel. km/sec	Number of stars	Mean vel. km/sec	Number of stars	Mean vel. km/sec
B	25	19.8	73	19.7	28	20.0	19	14.6	53	19.9	92	18.6
A	95	26.5	60	27.0	39	24 3	14	19.9	134	25.8	74	25.7
F	20	32.1	20	22.1	19	37.4	17	35.8	39	34.7	37	28.4
G	33	30.7	39	24.9	19	39.5	19	40.3	52	33.9	58	29.9
K	44	30.1	71	24 0	30	36.2	20	35.2	74	32.6	91	26.4
M	14	26.8	15	30.3	6	34.2	7	34.4	20	29.0	22	31.6
B-A	120	25.1	133	23 0	67	22.5	33	16 9	187	24.2	166	21.8
F G	53	31.3	59	23.9	38	38.4	36	38.2	91	34.3	95	29.3
K-M	58	29.3	86	25.1	36	35.9	27	35.0	94	31.8	113	27 4
All stars	231	27.6	278	23.8	141	30.2	96	30.0	372	28.6	374	25.4

The results of table III confirm the character of the distribution as shown by tables I and II. In the distribution of the velocity-vectors according to the values of „y" (the y-axis is nearly perpendicular to the direction of the line vertex-antivertex in the galactic plane) an increase of average velocities of stars with decreasing of the values of „y" takes place. Considering separate groups we see that not in all groups this distribution is observed. The number of stars in any separate group beeing relatively small the separate results are perhaps not reliable.

Wilno. 1928. X. 31.

WILNO UNIWERSYTET STEFANA BATOREGO