# On the question of the possible rotation of the local cluster.

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Dedicated to Professor František Nušl
on the occasion of his seventieth anniversary
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On the base of the study of the space velocities of 910 stars of $B$ type the author shows that the suplementary rotation of the so-called local cluster about a centre situated at $l = 237^0$ in the constellation of Carina in a distance of some hundred parsecs only does not exist.

In my previous work[1]) I gave new observational evidence of the galactic rotation. But H. Mineur showed[2]) that my demonstration did not settle the question of the possible sub-rotation about the second centre, i. e. the centre of the local cluster, which must be placed some hundred parsecs only from the Sun in the direction of gal. longitude $l = 237°$. I have shown in a comment on a paper by Edmondson,[3]) that this question may be solved by studying the motions of stars, which are placed in belts of space oriented towards gal. longitudes $l = 147°$ and $l = 327°$. I also mentioned, that I would return to this subject.

Consider a system of coordinates $X$, $Y$ in the galactic plane, the origin being the Sun. The axes $X$, $Y$ are oriented in the usual sense. Let $V_\odot$ denote the instantaneous rotational velocity of the Sun, $V_s$ the mean rotational motion of the stars in the solar vicinity, and $V_r$ the velocity of these stars relative to the Sun. If we take a new system of coordinates $X'$, $Y'$ in which $Y'$ is in the direction of $V_s$ then $X'$ is directed to the galactic centre, i. e. approximately to $l = 327°$. By this supposition we obtain the following relations:

$$\begin{aligned} V_\odot \cos \alpha_\odot &= V_s + V_r \cos \beta \\ V_r \sin \beta &= x'; \; V_r \cos \beta = y' \end{aligned} \tag{1}$$

[1]) J. M. Mohr, M. N. **92** (1932), 583.
[2]) H. Mineur, Bull. astron., **7** (1934), 397.
[3]) Edmonson, Astr. Journal, **44** (1935), No 1016, 16.

where $\beta$ is the angular distance between the Apex and the point towards which the mean rotational motion of the stars is directed, and $\alpha_\odot$ ist the angle between the direction of the rotational motion of the Sun and the direction of the mean rotational motion of the stars. It is also easy to see that following relations must exist:

$$\left.\begin{aligned} V_r^2 &= x^2 + y^2, \\ x' &= x \cos \alpha' - y \sin \alpha', \\ y' &= x \sin \alpha' + y \cos \alpha', \end{aligned}\right\} \tag{2}$$

where $\alpha' = 360° - 327° = 33°.$

From my previous discussion of $B$ stars,[4]) which I use also in this paper, it resulted that

$$V_r = 19{,}12 \text{ kmsec}^{-1}.$$

If we accept the value $V_\odot = 300$ kmsec$^{-1}$, towards $l_\odot = 55°$ then $V_s = 284{,}88$ kmsec$^{-1}$, towards $l_s = 56°\ 54'\ 24{,}7''$.

If as H. Mineur supposes, a secondary rotation does exist (i. e. if there does exist a second centre of rotation in the direction $l = 237°$ distant only a few hundred parsecs from the Sun), then for stars, whose coordinates of positions $Y'$ are less than zero, this rotation must be seen in the $x'$ (components of their space velocities). Besides the vector $V_1$ of the fundamental rotation, there must be present also the vector $V_2$ of the second rotation, so that the resultant of both vectors in different positions of space must be different in magnitude and in the direction.

Let $V_1$ denote the vectors of the fundamental rotation. The centre of this rotation is placed in the direction $l = 327°$. $V_2$ are the vectors of the possible suplementary rotation about $l = 237°$ for the group of stars with $Y' < 0$. The resultant motion of stars in the group I. of stars is $V_s'$, in the group II. $V_s''$ and in the group III. $V_s'''$. The angle between the vectors $V_1$ and $V_s'$ is $\alpha'_1$, between the vectors $V_1$ and $V_s''$ ist $\alpha'_2$, etc. Denote moreover by $V_\odot$ the instantaneous velocity of the Sun, which is compounded also from the vector of the fundamental rotation and the vector of sub-rotation for $Y' = 0$. (This latter vector is sensibly smaller than in the space where $Y' < 0$).

For $Y' = 0$, i. e. in the vicinity of the Sun, we get

$$V_\odot \sin \alpha_\odot + V_s \sin \alpha_2 = x',$$

where $\alpha_2$ is the angle between the vectors $V_1$ and $V_s$.

But for $Y' < 0$ we get similarly

$$V_\odot \sin \alpha_\odot + V''_s \sin \alpha'_2 = x'_2$$

[4]) Publ. de l'Institut Astron. de l'Université Charles de Prague, No. 19, 1936.

and

$$V_\odot \sin \alpha_\odot + V'_s \sin \alpha'_1 = x'_1; \qquad V_\odot \sin \alpha_\odot + V'''_s \sin \alpha'_3 = x'_3,$$

where
$$\alpha'_1 \lesseqgtr \alpha'_2 \lesseqgtr \alpha'_3$$

and
$$V'_s \lesseqgtr V''_s \lesseqgtr V'''_s,$$

either if the group I. is one of groups of stars situated in positive $X'$ and the group III. in negative $X'$, or vice versa. But if the groups I. and III. of stars are at the same distance from the axis $Y'$, so that

$$|X'_1| = |X'_3|,$$

then the ratio of the change of $\alpha'_1$ compared with $\alpha'_3$ and of $V'_s$ to $V'''_s$ is given by the relation

$$\frac{V'_s}{V'''_s} = \frac{\sin \alpha'_3}{\sin \alpha'_1}.$$

so that

$$x'_1 = x'_3 > x'_2, \tag{3}$$

because the components $x'_1$, $x'_2$, $x'_3$ are negative.

If we suppose for simplicity that the vector of the fundamental rotations is independent of $X'$ (this supposition may be made owing to the great distance of the centre of rotation), then considering groups of stars placed in $Y' < 0$, the component $x'$ of the space velocity for $X' = 0$ must reach a maximum negative value. For values $X' \gtrless 0$ this component $x'$ must gradually reach lower negative values.

The values $x'_1$, $x'_2$, $x'_3$ are easily obtainable if we know the components $x$, $y$, $z$ of space velocities of the stars as shown by formulas (1) and (2).

But how is realised the inequality (3) by the computation? If we divide the space round the Sun in three parts so, that the first part contain all stars, which $Y' > +150$ parsecs, the second part contain all stars, which $Y' = \pm 150$ parsecs, the third part contain all stars, which $Y' < -150$ parsecs, then the computed values of $x'$ for different $X'$ are given in Table I.

Table I.

$Y' > +150$ parsecs.

| | | | | | | |
|---|---|---|---|---|---|---|
| $X'$ (parsec) | —502,66 | —147,81 | — 49,59 | + 50,48 | +189,00 | +419,16 |
| $Y'$ (parsec) | +379,03 | +344,31 | +302,27 | +284,98 | +364,84 | +393,96 |
| $x'$ (kmsec$^{-1}$) | + 2,31 | + 5,39 | + 3,41 | + 3,48 | + 3,03 | + 17,08 |
| Number of stars | 17 | 39 | 32 | 37 | 27 | 5! |

$Y' = \pm$ 150 parsecs.

| | | | | | | |
|---|---|---|---|---|---|---|
| $X'$ (parsec) | —427,71 | —168,90 | —47,98 | +50,56 | +155,00 | +362,48 |
| $Y'$ (parsec) | — 7,64 | — 19,12 | — 5,14 | —36,30 | — 21,06 | — 75,20 |
| $x'$ (kmsec$^{-1}$) | — 13,70 | — 11,12 | —12,12 | — 8,55 | — 9,53 | — 14,08 |
| Number of stars | 24 | 122 | 167 | 204 | 103 | 8! |

$Y' < -$ 150 parsecs.

| | | | | | | |
|---|---|---|---|---|---|---|
| $X'$ (parsecs) | —491,00 | —178,45 | — 36,08 | + 45,34 | +175,67 | +337,30 |
| $Y'$ (parsecs) | —265,05 | —225,64 | —208,80 | —199,87 | —250,61 | —530,43 |
| $x'$ (kmsec$^{-1}$) | — 28,00 | — 15,51 | — 11,80 | — 11,67 | — 50,00 | — 44;63 |
| Number of stars | 16 | 28 | 46 | 25 | 7 | 3 |

The Table I. shows, that $x'$ remains nearly constant in the groups where $Y' > +$ 150 parsecs and $Y' = \pm$ 150 parsecs. The dependence of the $x'$ on $X'$ in the group $Y' < -$ 150 parsecs does not show in the suplementary rotation about the centre $l = 237°$. Although there are a smaller number of stars in this group, especially for large positive $X'$, it can be seen, from the values $x'$ between $X' = -$ 491,00 parsecs and $X' = +$ 45,34, where we find a homogeneous number of stars, that the behaviour of the values $x'$ is just in the opposite sense to that which would be, if the suplementary rotation did exist.

This ascertained distribution of the components $x'$ in various parts of space has of course a great significance for, for instance, the $K$ term. Because the distribution of the components $x'$ in the parts of space, the $Y'$ of which is $Y' > +$ 150 and $Y' = \pm$ $\pm$ 150 parsecs, is regular, it is clear that we should have from this material of stars the possibility to obtain a value of the $K$ term not affected by the perturbing influence of the star-streaming. In the space where $Y' < -$ 150 parsecs the observed dependence of $x'$ on $X'$ is probably caused not only by the rotation of the Galaxy but probably by the star-streaming. By this star-streaming the velocity-ellipsoids in those parts of space are deformed.

Therefore if we would find the real value of the $K$ term we must separate all deformations from the observed velocity-ellipsoids. I myself[5]) tried a case unreally, but for the time being important for the knowledge of the real velocity-ellipsoids in different parts of space in order to find in the future what is the real form of

[5]) J. M. Mohr, Publ. de l'Institut Astron. de l'Université Charles de Prague, No. 19. 1936.