(*a*) *The Standard Solar Motion.* The solar motion elements

$$A = 18^h = 270°, \; D = +30°, \; V_0 = 20 \text{ km/sec}$$

have been widely used to perform the reduction to the 'local standard of rest'.

(*b*) *The Basic Solar Motion.* Vyssotsky and Janssen (*A.J.* **56,** 58, 1951) have given arguments suggesting that the elements

$$A = 265°.0 \pm 1°.2, \; D = +20°.7 \pm 1°.4, \; V_0 = 15.5 \pm 0.4 \text{ km/sec}$$

are the correct reduction to the 'local standard of rest'.

B. DISCUSSION

It should be noted that only the changes in the Y-component in Table I are systematic. These are related to the two major factors of (*a*) velocity dispersion and (*b*) distance.

The velocity-dispersion effect may be explained in principle by reference to the well-known Haas-Bottlinger diagram. A large velocity dispersion means large deviations from circular motion with a resulting average rotational velocity that is smaller than the circular velocity. Stromberg (*Ap.J.* **61,** 363, 1925) found a quadratic relation between the Y-component and the dispersion along the same axis:

$$y' = -0.0192\, \sigma^2(y') - 10.0 \text{ km/sec}$$

This effect will explain the K-star solar motion, but not the B-star solar motion.

The B-star solar motion can be explained by another effect, a second-order galactic rotation term in the Y-component which varies as the square of the distance from the Sun (Edmondson, *Handbuch der Physik* **53,** 14, 1959). This statement is only qualitative, owing to the distance-scale uncertainties.

The conclusion of Vyssotsky and Janssen regarding the reduction to the 'local standard of rest' seems to be justified.

3. THE CONSTANTS OF DIFFERENTIAL GALACTIC ROTATION

J. H. Oort

These constants were originally defined as follows

$$A = \frac{1}{2}\left(\frac{\Theta_c}{R_0} - \frac{\partial \Theta_c}{\partial R}\right), \quad B = -\frac{1}{2}\left(\frac{\Theta_c}{R_0} + \frac{\partial \Theta_c}{\partial R}\right),$$

or, alternatively by

$$A = -\tfrac{1}{2} R_0 \frac{\partial \omega_c}{\partial R}, \quad A - B = \omega_c$$

R_0, Θ_c, ω_c referring to the region near the Sun.

For $|R - R_0| << R_0$, we have

$$V = -2A(R - R_0) \sin l^{II}$$

For $r << R_0$ we get

$$V = r\, A \sin 2l^{II}$$

$$4.74\, \mu_l = B + A \cos 2l^{II}$$

In these expressions, which are for objects in the galactic plane, r is the distance from the

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Sun, V the radial velocity corrected for solar motion, and μ_l the proper motion in galactic longitude, also corrected for solar motion.

From the beginning it appeared that there was considerable regularity in the differential motions, and it looked as though A and B could be derived with considerable accuracy, once the distance scale was known. It is noteworthy, in this connection, that there is not only great regularity but also the line perpendicular to the differential motions points almost exactly to the centre. It came out as about 325°, old longitude, while the direction to the centre is 327°·7. There is a difference between the two directions but it is small.

The 21-cm data, however, show that there may be local deviations from circular motion up to 10 km/sec, or so. These might well influence the determination of A based on a relatively small region.

For this reason we prefer to define A as $\frac{1}{2}R_0$ times the derivative of $\omega_c(R)$, ω_c being *smoothed* over as large an interval as practicable.

There remains the uncertainty in the distance scale, which Blaauw estimates as about 20% (p.e.).

The following table lists some of the principal determinations of A from radial velocities.

Authors	Ref.	Type of stars	Region	A
Petrie, Cuttle and Andrews	(1)	B	north	17·7
Feast and Thackeray	(2)	B	whole sky	17·5 ± 1·5
Blaauw	(3)	B 2–5	north	20·0 ± 1·8
Stibbs	(4)	Cepheids	whole sky	19·5 ± 1·9
Gascoigne and Eggen	(5)	Cepheids	whole sky	18·4
Walraven, Muller and Oosterhoff	(6)	Cepheids	south	17·4 ± 2·1
H. L. Johnson and Svolopoulos	(7)	clusters	north	15

References:

(1) *A.J.* **61,** 289, 1956.
(2) *M.N.* **118,** 125, 1958.
(3) *Trans. IAU* **8,** 505, 1952.
(4) *M.N.* **116,** 453, 1956.
(5) *A.J.* **63,** 199, 1958 (abstract only).
(6) *B.A.N.* **14,** 81, 1958.
(7) *Ap.J.* **134,** 868, 1961.

The errors indicated in the table are mean errors. The last determination is to be noted particularly, as the distance calibration in this case should be much more direct and more reliable than in the other cases.

Determinations of A and B have also been made from proper motions. These are independent of the distance scale, but refer to only a small region of space and a small number of stars. The most recent result (Morgan and Oort, *B.A.N.* **11,** 379, 1951) is

$$A = 20 \pm 2, B = -7 \pm 1{\cdot}5$$

As a compromise value we might take $A = 17{\cdot}5$. It should be stressed, however, that this value is still quite uncertain, much more so than might be inferred from the fair agreement between most values in the table. In their recent exhaustive discussion of Cepheids based on Kraft's new distance scale, Schmidt and Kraft arrive at values which are very considerably lower, of the same order as that found by Johnson (still unfinished). (See the reported discussion.)

Information that is very important, because it refers to a large region of space and is independent of the distance scale, can be derived from 21-cm observations. These give the product AR_0. As an average between northern- and southern-hemisphere observations I adopt

$$A R_0 = 150 \pm 10 \text{ (m.e.)}$$

Another entirely independent result comes from the ellipsoidal distribution of stellar motions. The most informative result which refers to regions at about 1 kpc distance in all directions north of $-20°$ declination is that derived by Hins and Blaauw (*B.A.N.* **10,** 365, 1948), who find for the ratio of the squares of the average velocities along the two galactic axes

$$h^2/k^2 = -B/(A-B) = 0{\cdot}24.$$

However, it should be noted that all determinations referring to brighter stars give a considerably higher value for this ratio. A representative result for these is about 0·40.

With $A = 17{\cdot}5$ the two results for h^2/k^2 give $B = -5{\cdot}5$ and $-11{\cdot}7$ respectively. As an average, including the direct determination of B from proper motions, we might adopt $B = -8{\cdot}5$. With $A = 15$, we would get $B = -7{\cdot}5$.

From the constants A and B and the above value of AR_0 we can derive R_0 and Θ_c, the circular velocity near the Sun. The latter is equal to $A R_0 - B R_0$. With $A R_0 = 150$ we obtain the following values:

For $A = 17{\cdot}5$ and $B = -5{\cdot}5$ or $-11{\cdot}7$: $R_0 = 8{\cdot}6$ kpc, $\Theta_c = 197$ or 251 km/sec, respectively.

For $A = 15{\cdot}0$ and $B = -7{\cdot}5$: $R_0 = 10{\cdot}0$ kpc, $\Theta_c = 150 + 75 = 225$ km/sec.

The standard values which up to the present have been used in the reductions of 21-cm observations are

$$A = 19{\cdot}5,\ B = -6{\cdot}9,\ R_0 = 8{\cdot}2 \text{ kpc},\ \Theta_c = 216 \text{ km/sec}.$$

Several astronomers have argued that Θ_c must be higher. The maximum value admissible in view of the 21-cm data and the ellipsoidal distribution of velocities would seem to be about 260 km/sec; the true value is likely to be rather lower.

SOME DESIDERATA FOR IMPROVING THE CONSTANTS

1. Most important is the direct determination of R_0 from RR Lyrae variables in the central region.

2. The value of AR_0 can be improved by a better determination of line profiles in the Southern Milky Way.

3. Measurement of proper motions of stars of 14th and 15th magnitude relative to faint galaxies in the Lick survey may yield $\omega_c = A-B$ with a probable error of about $0''{\cdot}0002$. A similar accuracy can be obtained for A. These determinations will be independent of the distance scale.

4. The Lick survey will similarly yield values of h^2/k^2 which are much superior in accuracy to what is known at present.

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