

MOTIONS OF NEAR-POLAR K-GIANTS ALONG THE Z-COORDINATE

A.N. BALAKIREV

*Sternberg Astronomical Institute
Moscow University
Moscow, U.S.S.R.*

The motion of G8-K5 III, IV stars near galactic poles ($|b| > 60^\circ$) was investigated. The main attention was paid to motion in the z-direction. The spectral types, visual magnitudes, colors and radial velocities (v_r) were taken mainly from Schild (1973), Heard (1956), Blanco et al (1968) and Wilson (1953). To reduce the values v_r by Heard to those by Wilson, the correction of -1 km/sec was made. The stars with variable v_r and spectroscopic binaries were excluded from the investigation.

The study of motion was made by least-squares solution of the system of conditional equations taken at first (calculation 1) in the form

$$-v_r = U_\odot \cos l \cos b + V_\odot \sin l \cos b + W_\odot \sin b \quad (1)$$

where U_\odot , V_\odot , W_\odot are the solar motion components relative to the investigated stars. In order to ascertain whether the value W_\odot changes with z-coordinate, we made calculation 2, having replaced in (1) the value W_\odot by value $(W_\odot + (dW_\odot/dz) z)$. The z-coordinates were defined as the heights above the galactic plane, assuming the Sun's height $z_\odot = 10$ pc. The distances r were found mainly as luminosity-distances. The intrinsic colors and absolute magnitudes were taken from Bulon (1963) and the ratio $R = A_v / E_{B-v} = 3.0$ was adopted. The results of calculations for different groups of stars are presented in the Table, where n is the number of stars. The components of the solar motion found by Vyssotsky and Janssen (1951) (group F) and those relative to G8-K5 III, IV stars from Woolley et al (1970) (group D) are also listed. The stars of these groups belong to the disk population. Although the values U_\odot and V_\odot are determined with uncertainty for the investigated stars, still the difference between those values for the groups A, B and C on the one hand and the groups D and F on the other hand appears to be real. This distinction may be accounted for by the presence of the old disk and halo objects among the investigated stars.

Group of stars	Calculation 1				Calculation 2	
	U_{\odot} km/sec	V_{\odot} km/sec	W_{\odot} km/sec	n	dW_{\odot}/dz km/sec/kpc	n
A ($b > 60^{\circ}$)	7.8 ± 7.6	41.4 ± 10.3	7.0 ± 1.8	157	15 ± 32	89
B ($b < -60^{\circ}$)	2.6 ± 8.4	13.1 ± 7.4	4.8 ± 2.3	87	30 ± 50	79
C ($ b > 60^{\circ}$)	8.6 ± 5.7	26.4 ± 6.3	6.5 ± 1.5	245	7 ± 15	169
D	8.8 ± 3.6	13.7 ± 2.7	6.3 ± 2.2	49		
F	10	10	6.2			

The quantity dW_{\odot}/dz is determined with great uncertainty, although it is quite possible that the small positive value of it is real. This should mean that the subsystem of investigated stars is contracting towards the galactic plane, the farther the stars outward from the plane the greater the speed of contraction. But further we shall assume that $dW_{\odot}/dz = 0$.

The residual radial velocities (Δv_r) contain information on peculiar W -velocities of the investigated stars (w). The knowledge of w makes it possible to determine the dynamic parameter C in the form (see Kuzmin, 1952) :

$$C^2 = (\sigma_w^2 / \sigma_z^2) = - (d^2\Phi / d^2z)_0 \quad (2)$$

where Φ is the galactic potential for the unit mass, σ_z^2 is the dispersion of z and σ_w^2 is the dispersion of w of investigated stars. The parameter C is related to the constants of differential galactic rotation A and B by Poisson's law

$$4\pi G\rho = C^2 - 2(A^2 - B^2) \quad (3)$$

where G is the gravitational constant and ρ is the total mass density near the Sun.

To find C we shall use the values Δv_r instead of true values w . Such substitution results in the increase of the value σ_w^2 relative to reality and therefore, according to (2), in the increase of the value C . But the nearer the star is to the pole, the more accurate is the assumption that Δv_r is equal to w . Using the stars with $|b| > 75^{\circ}$ (group 1, 60 stars) and with $|b| > 84^{\circ}$ (group 2, 18 stars) we found C equal to 157 ± 14 km/sec/kpc and to 103 ± 17 km/sec/kpc, respectively. Having substituted $A = 15$ km/sec/kpc, $B = -10$ km/sec/kpc and $C = 103 \pm 17$ km/sec/kpc in (3) we found $\rho = 0.15 M_{\odot}/pc^3$. Such total mass density does not correspond to the observed mass density near the Sun, $\rho_{obs} \approx 0.09 M_{\odot}/pc^3$, universally recognized at present. The investigated stars appear to be a mixture of disk population, old disk population and halo objects. But the formula (2) is strictly correct only near the galactic plane, where the condition

$$d^2\phi / d^2z = \text{const} = -C^2 \tag{4}$$

is satisfied. Therefore only the disk population stars may be used for such study. Besides, such mixture results in the increase of velocity dispersion and in the increase of value C. But there is no method for classification of each star under investigation according to population type.

We try to do this with the help of modulus w - modulus z ($|w|-|z|$) graph (Fig.1). In the region where the condition (4) holds, the stars move along the z-coordinate according to the law (see Parenago,(1954)

$$\ddot{z} = (d^2\phi / d^2z) z = -C^2z \tag{5}$$

where \ddot{z} is the acceleration. Then the trajectory of the star's motion in the coordinate plane w - z is an ellipse with semiaxes Z^0 and $W^0 = C Z^0$, where Z^0 is the amplitude in the z-direction and W^0 is the amplitude of the w-velocity. Suppose that the quantity C is close to that found by Oort (1932) ($C^0 = 73 \text{ km/sec/kpc}$), which corresponds to the total mass density $\rho = \rho_{\text{obs.}} = 0.09 \text{ Mo/pc}^3$ exactly. This condition leads to some trajectories in the plane w - z (see Fig.1). The curve 1 is such a trajectory with amplitude $Z^0 = 500\text{pc}$ and the curve 2 is that with amplitude $Z^0 = 360\text{pc}$. If the investigated stars move according to the law (5) (i.e. are the disk population stars) the stars below the curves may not have z-coordinates higher than the corresponding Z^0 .

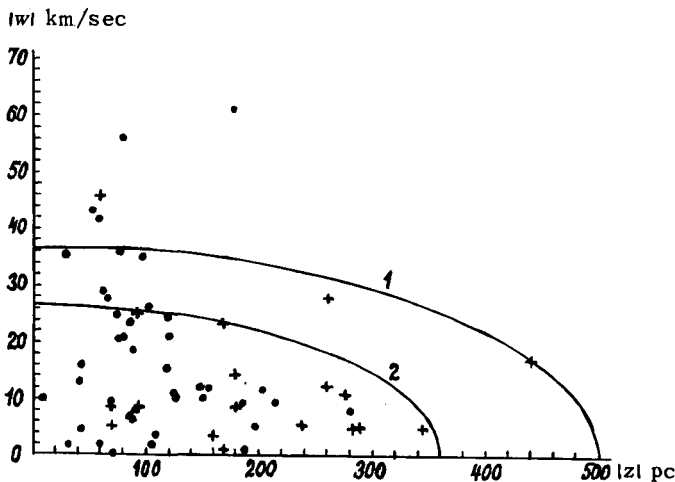


Figure 1. The $|w|-|z|$ graph for stars with $|b| > 75^\circ$; crosses are the stars with $|b| > 84^\circ$, points are all the other stars.

Using the stars of group 2 below the curve 1 we obtain $C = 79 \pm 13$ km/sec/kpc and using those stars below the curve 2 we obtain $C = 76 \pm 14$ km/sec/kpc. Hence the flatter the stars we study, the nearer to C_0 is the quantity of the dynamic parameter. The value $C = 76 \pm 14$ km/sec/kpc corresponds to $\rho = 0.11 \pm 0.02 M_{\odot} / \text{pc}^3$. That is in good agreement with $\rho_{\text{obs.}}$, the observed mass density near the Sun.

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