THE STELLAR KINEMATICS IN THE MAIN MERIDIONAL SECTION OF THE GALAXY

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ABSTRACT. In the framework of the programme of studying the meridional section of the Galaxy (MEGA) the catalogue of stellar data (about 26500 stars) had been compiled and investigated. The main part of the catalogue consist of the proper motions of stars with respect to the galaxies. The stellar kinematical characteristics in the direction of the galactic rotation, the parameters of velocity ellipsoid and the relation between kinematical, spatial and chemical properties of stellar populations have been determined.

During the last ten years at the Main Astronomical Observatory of the Ukrainian Academy of Sciences and some others observatories the investigations on the programme of the meridional section of the Galaxy (MEGA) are being carried out (Einasto, *et al.*, 1985). The meridional section is the plane crossing the galactic rotation axis and the Sun. The goal of the MEGA programme is study of the kinematics and spatial structure of physically and evolutionary homogeneous stellar groups and specification of Galaxy models. In contrast to similar works, e. g. Basle Halo programme (Becker, 1965), the MEGA programme includes larger set of stellar data: astrometric, photometric and spectral, and moreover permits to derive the Galaxy kinematics from stellar proper motions with respect to galaxies or practically in the inertial system. The study of area near the galactic meridian has the following advantages:

- the spatial velocity components in the direction of the galactic rotation can be determined by using only stellar proper motions and distances and it is valid also for the galactoradial velocity component at the galactic poles without any knowlidge of radial velocities;
- due to the axially symmetry of the galactic structure the meridian is well suited for study the radial and verti-

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cal gradients of galactic parameters.

The basis of MEGA programme is observational data in 64 fields distributed within 30° from the galactic meridian. The centers of fields have been fixed by the available astrometric plates which can serve as the first epochs for determining the proper motions with respect to galaxies at the Main Astronomical Observatory in Kiev (Kharchenko, 1983) and at Institute for Astrophysics in Potsdam (Schilbach, 1987).

During the progress of the MEGA programme some improved measuring techniques and methods have been developed for determining stellar characteristics and achieving their higher accuracies. Since this time, the following sets of observational data have been obtained:

- proper motions with respect to galaxies for about 26500 stars with mean square error $\varepsilon = \pm 0.009$ arcsec/year and stellar B - magnitudes estimates with $\varepsilon = \pm 0.3$ mag down to limited B = 15.5 mag in 47 fields (for 933 stars radial velocities, UBV - magnitudes, spectral and luminosity classes in various catalogues have been found) (Kharchenko, 1989);
- photoelectric UBVR - magnitudes for more 1000 stars with $\varepsilon = \pm 0.01$ mag down to V = 15 mag in 47 fields (Andruk *et al.*, 1991);
- photoelectric radial velocities for 125 stars with $\varepsilon = \pm 0.3$ km/sec down to V = 13 mag and photoelectric seven-colour Vilnius photometry for 192 stars with $\varepsilon = \pm 0.01$ mag down to V = 13.6 mag in three fields near the North Galactic Pole (Bartashiute, 1984; 1986);
- spectral data (effective temperatures with $\varepsilon = \pm 120^{\circ}$, absolute stellar magnitudes with $\varepsilon = \pm 0.8$ mag and metal abundances [Fe/H] with $\varepsilon = \pm$o.25 dex down to B = 12 mag) from 8 - degree objective prism plates for 184 G5-K5 stars in two fields in North Galactic Pole (Maluto *et al.*,1989).

These observational data, although far from being adequate to answer all questions adressed in MEGA programme, allowed to determine and perform an analisis of the stellar kinematical characteristics and the relation between kinematical, spatial and chemical properties of stellar populations.

The bulk of observational data consists of the proper motions with respect to galaxies. The observations have been obtained using the long-focus astrograph in Kiev. The catalogue system have been derived from comparison of absolute proper motions from individual catalogues of the Faint Stars Plan, AGK3 and SAO. The first results based on by these data (the precession constants corrections and secular parallaxes) have been presented to the IAU Symposium No.141 (Kharchenko, 1989). Now these data were used for stellar kinematics. The mean distances were estimated by secular parallaxes and luminosity function and corrections for interstellar absorbtion. The proper motions and velocity components were corrected for systematical and random errors and the Sun motion relatively to the Local Standard of Rest. The directions of axises Galaxy coordinate system X, Y, Z are to the anticentre, rotation direction and North Pole of the Galaxy, respectively.

Table 1 gives the kinematical characteristics for high-galactic-latitute stars. Here ω is angular rotation velocity around the galactic Z-axis and σ is velocity dispersion. The principal features to be noted from the Table 1 are that with increasing of z-distance (that is, with increasing of stellar ages) the rotation velocity decreases and the rotation law is approaching to a solid body rotation low. It can be concluded that during the time of formation of old stellar populations the mass of the Galaxy was distributed more uniformly.

Table 1. Kinematical characteristics of stars in meridional section

$\bar{z}$, kpc	$\bar{\omega}$, km/s/kpc	$d\omega/dX$, km/s/kpc^2	$d\sigma_Y/dX$, km/s/kpc
0	25	-3	-
0.7	23.0 ±0.4	-2.0 ±0.7	-12 ±7
1.1	21.9 ±0.6	-0.9 ±0.7	-6 ±5
1.6	20.6 ±0.4	-0.4 ±0.3	-12 ±8

The coefficients of Stremberg equation $\bar{V}_Y = a\,\sigma_Y^2 + b$ and parameters of the velosity ellipsoid were calculated separately in the North and South parts of the meridional section (Table 2). These characteristics bear information about the dynamical state of a stellar system. The identity of these characteristics in the galactical hemispheres speaks about the dynamical, that is, kinematical and spatial symmetry of the Galaxy relatively to its equatorial plane.

Table 2. Kinematical characteristics of stars in North and South parts of meridional section

Characteristic	North	South
a (from $\bar{V}_Y = a\,\sigma_Y^2 + b$)	-0.0058 ±0.0005	-0.0053 ±0.0006
b	-19 ±5	-18 ±8
$\sigma_X : \sigma_Y$	1 : 0.75	1 : 0.78
Vertex deviation	14°	12°

For 933 stars individual distances, space velocity components and galactic orbit eccentricities, e, used the galactic potential model of Saio and Yoshii (1979) have been calculated (Table 3). This sample was divided into different groups in accordance with ages and galactic subsystems (thin or more young disk and thick or more old disk) by physical and kinematical signs. It is known in case of stationary stellar system has to be fulfiled the following conditions for parameters of velocity ellipsoid: $\sigma_X \cong \sigma_Y$, σ_Z is minimal or maximal and a vertex deviation equals zero. But in many investigations opposite results had been received (e.g. present work, table 2), because of stellar groups of mixed ages had been treated. The results of the table 3 show that for young disk stars the axises relation of the velocity ellipsoid is: $\sigma_X \cong \sigma_Y$, σ_Z is minimal. The vertex deviations are $+15^\circ \pm 2$ for all stars and $-3 \pm 7^\circ$, $+1 \pm 5^\circ$ for the young disk and old disk stars separately. The nonzero signification of the vertex deviation is the consequence of relative removal of different age stellar groups on the plane (V_X, V_Y). Therefore kinematical and evolutional mixing of stars in studied groups leads to the distortion of the form and spatial orientation of the velocity ellipsoid.

Table 3. Characteristics of young (the first line for any group) and old (the second line) disk subsystems

Stellar group	$\bar{V}_X$, km/sec	$\bar{V}_Y$, km/sec	σ_X, km/sec	σ_Y, km/sec	σ_Z, km/sec	$\bar{e}\ 10^3$
Giants G5-M	-7 ±2	+4 ±1	13 ±1	7 ±1	13 ±1	127 ±11
	-2 ±3	-18 ±2	28 ±2	15 ±1	13 ±1	137 ± 8
Subgiants	-11 ±2	+8 ±1	11 ±1	7 ±1	8 ±1	110 ± 9
	+14 ±3	-8 ±2	11 ±2	8 ±2	11 ±2	123 ±15
Dwarfs A,	-9 ±1	+8 ±1	8 ±1	5 ±1	7 ±1	85 ± 6
nonclassif.A	+7 ±2	-8 ±1	15 ±1	8 ±1	8 ±1	100 ± 7
Dwarfs F,	-16 ±1	+8 ±1	11 ±1	6 ±1	8 ±1	101 ± 6
nonclassif.F	+ 8 ±2	- 9 ±1	17 ±1	9 ±1	8 ±1	113 ± 5
Dwarfs G-M	+4 ±2	+5 ±2	13 ±2	9 ±1	13 ±2	124 ±12
	-13 ±5	-9 ±3	25 ±4	15 ±2	10 ±2	128 ±14

The astrophysical data: spectral classes, absolute magnitudes and metal abundances [Fe/H] were resulted from photometric classification in the Vilnius system and quantitative spectral classification from objective prism plates. This stellar sample was divided into three metallicity groups: [Fe/H] > -0.4, -0.4 > [Fe/H] > -1.0 and [Fe/H] < -1.0, that represent the thin disk, thick disk and halo populations, respectively. Table 4 gives the characteristics for these three groups.

Table 4. Characteristics for stars of different metallicity groups

[Fe/H]	$\bar{V}_Y$, km/sec	σ_Y, km/sec	$\bar{e}\ 10^3$	n/N
> -0.4	-10 ± 3	37 ± 2	201 ±10	0.98
-0.4 - -1.0	-21 ± 8	61 ± 6	301 ±12	0.02
-1.0 - -2.6	-73 ±21	105 ±15	481 ±21	0.003

Here the spatial density relatios, n/N, for different populations in the solar neighborhood have been defined by combining both kinematical and chemical stellar characteristics and extrapolating down to the galactic plane.

The continuation of the observational compaign and receaches of the MEGA programme will give possibility to obtain more detailed quantitative characteristics of stellar populations and to get deeper insight to the Galaxy kinematics and evolution.

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