The open clusters motion under the action of the Gould Belt in the revolving Galaxy

L.V. Smirnova,

Yaroslavl State Pedagogical University

The equations of motion

The equations of motion of a star moving in the galactic plane, in curvilinear system of coordinates [5], are

$$\begin{cases} m[\ddot{x} - 2\omega_0\dot{y} - \omega_0^2(r+x)] = m\dfrac{r+x}{R}\dfrac{\partial U}{\partial R} - \dfrac{\partial U_1}{\partial x} \\ m[\ddot{y} + 2\omega_0\dot{x} - \omega_0{}^2 y] = m\dfrac{y}{R}\dfrac{\partial U}{\partial y} - \dfrac{\partial U_1}{\partial y} \\ m\ddot{z} = m\dfrac{\partial U}{\partial z} - \dfrac{\partial U_1}{\partial z} \end{cases} \quad (1)$$

The Gravitation potential of the Galaxy [4] is

$$U(x,y,z) = \sum_{i=1}^{3} \frac{GM_i}{\sqrt{(r+x)^2 + y^2 + (a_i + \sqrt{b_i^2 + z^2})^2}} \quad (2)$$

Let's consider the Gould belt as ellipsoid with axes a, b, c and with even distribution of density [3]. That equation of the motion is:

$$\begin{cases} \ddot{x} = 2\omega_0\dot{y} + \omega_0^2(r+x) - \sum_{i=1}^{3} \dfrac{GM_i(r+x)}{((r+x)^2 + y^2 + (a_i + \sqrt{b_i^2 + z^2})^2)^{3/2}} - \dfrac{1}{m}\beta_1 x \\ \ddot{y} = -2\omega_0\dot{x} + \omega_0{}^2 y - \sum_{i=1}^{3} \dfrac{GM_i y}{((r+x)^2 + y^2 + (a_i + \sqrt{b_i^2 + z^2})^2)^{3/2}} - \dfrac{1}{m}\beta_2 y \\ \ddot{z} = -\sum_{i=1}^{3} \dfrac{GM_i z}{((r+x)^2 + y^2 + (a_i + \sqrt{b_i^2 + z^2})^2)^{3/2}} \dfrac{a_i + \sqrt{b_i^2 + z^2}}{\sqrt{b_i^2 + z^2}} - \dfrac{1}{m}\beta_3 z \end{cases} \quad (3)$$

The information about the open star clusters, such as radial velocity, galactic longitude and latitude, are taken from the catalogue DAML [1], where the list of 1787 open clusters In this paper use 497 clusters with the known proper motions are presented, 33 of that clusters belong to the Gould belt.

The LSR velocity of 220 km/s was adopted according to the IAU recommendation, for the galactocentric distance of the Sun of 8.5 kpc. The results of the numerical integration of the system of the differential equations (3, 4) are given in figure 1. All orbits were found to be box ones.

Correlations of orbital elements and physical parameters of the clusters

The open cluster's positions of the Gould belt at the moments of time 0, 10, 30, 50, 60 and 100 mln.years are illustrated in Fig. 2

We considered two dimensionless orbital elements,

$$c = \frac{2z_{\max}}{(r_{\max} + r_{\min})} \tag{4}$$

$$e_x = \frac{|x_{\max}| - |x_{\min}|}{|x_{\max}| + |x_{\min}|} \tag{5}$$

All of the open clusters were divided into the following groups:

Group A is all 479 of open clusters. Group B is the open clusters with galactocentric distances less than 1000 kpc. Group C is the clusters of the Gould belt. The coefficients of the correlation parameters are illustrated in the tables 1-3.

From tables 1-3 we make the following conclusions:

- Linear dependency between metallicity [Fe/H] and age τ of the clusters of the group B is revealed (but not for the others open clusters).
- For the color excess and distance from a cluster of the group B coefficient of correlation is equal to 0.496. We consider this value as characteristic (peculiarity) for the clusters.
- We found that coefficients of correlations for the functions (log(τ), e_x), (log(τ),c) and (V-B, e_x) are equal 0.54, 0.24, and 0.28, consequently, for open clusters of the Gould belt, and the corresponding coefficients of correlations tend to zero for the others groups.

References:

1. DAML (version 2.10 - feb/17/2009) [On-line Data Catalog]// Dias W. S., Alessi B. S., Moitinho A. and Lépine J. R. D - Astron&Astrophys. - 2002. - v.389.
2. Olano C.A On a model of local gas related to Gould's Belt.//Astron&Astrophys 1982. - V.112. - P.195
3. Jasevicius V. The Galaxy gravitation potential in a stackel approximation [Текст]./Baltic Astronomy, 1994. - V.3. - P. 232.
4. Chandrasekhar. S. Dynamics of star cluster. - 1948. - P.263.

	[Fe/H]	Age т	c	e_x	$r_{(t=0)}$
[Fe/H]	1	-0,177877304	-0,115975098	0,217304754	-0,520569123
Age		1	-0,008554083	-0,037131745	0,046532246
V-B			0,019038234	-0,058844054	0,26726418
c			1	0,521907507	0,036581034
e_x				1	-0,237997019

Table 1. The coefficients of the Correlation from **Group A**

	[Fe/H]	Age	c	e_x	$r_{(t=0)}$
[Fe/H]	1	0,268204362	-0,11744642	0,003064476	-0,146931039
Age		1	-0,065760327	-0,081261502	-0,146805788
V-B			0,059694892	0,006757635	0,496046667
c			1	0,526895737	0,175122255
e_x				1	-0,09032679

Table 2. The coefficients of the Correlation from **Group B**

	[Fe/H]	Age	c	e_x	$r_{(t=0)}$
[Fe/H]	1	0,392968815	-0,504022289	0,270151548	-0,112836328
Age		1	0,235765052	0,535061017	0,198436388
V-B			0,065694697	0,284620495	0,140252624
c			1	0,420588348	-0,050921772
e_x				1	0,17766735

Table 3. The coefficients of the Correlation from **Group C**

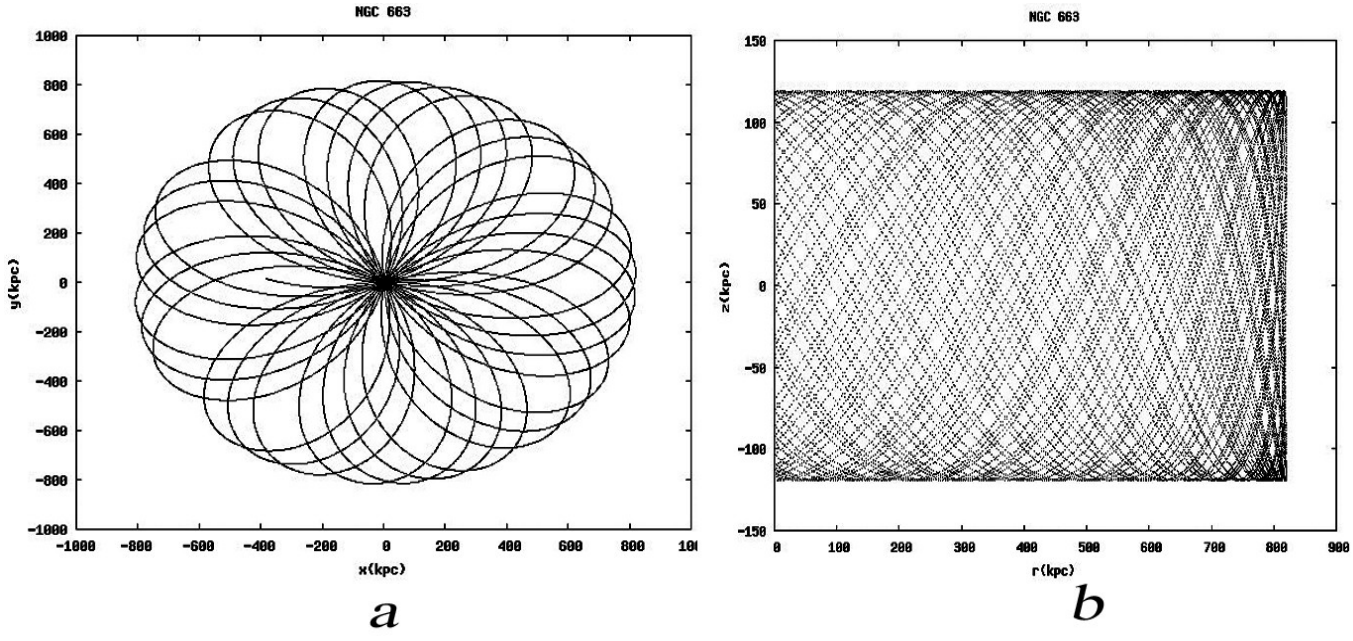

Fig. 1Typical orbit, for open cluster NGC 663

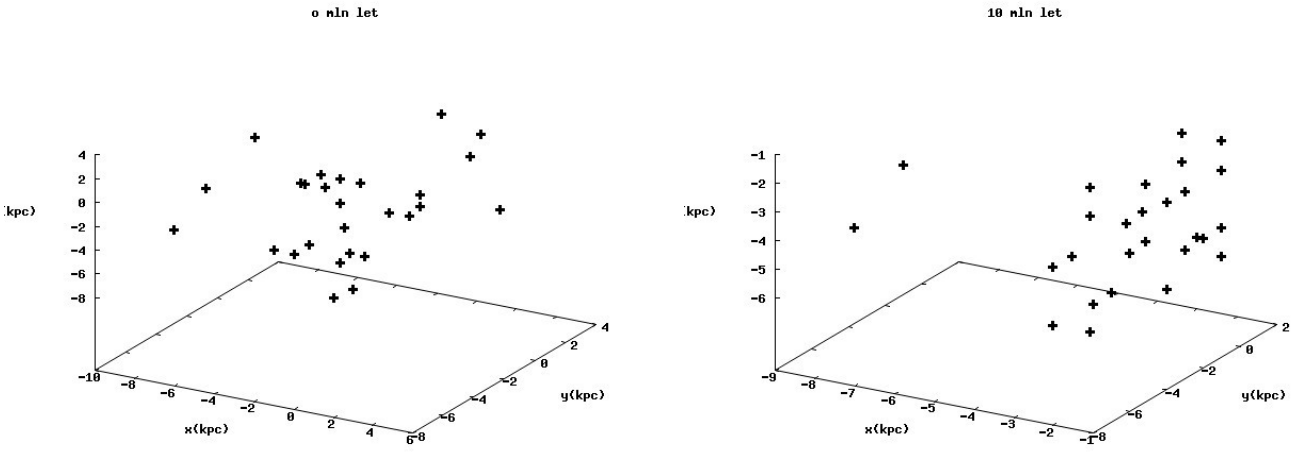

Fig 2 The open cluster's positions of the Gould belt at the moments of time 0, 10 mln.years

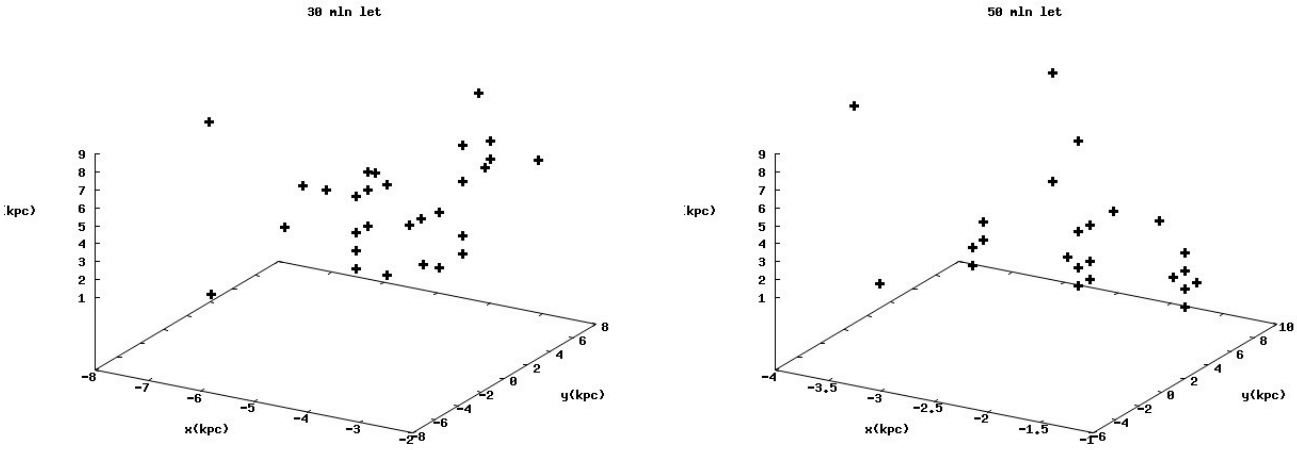

Fig 2 The open cluster's positions of the Gould belt at the moments of time 30, 50 mln.years

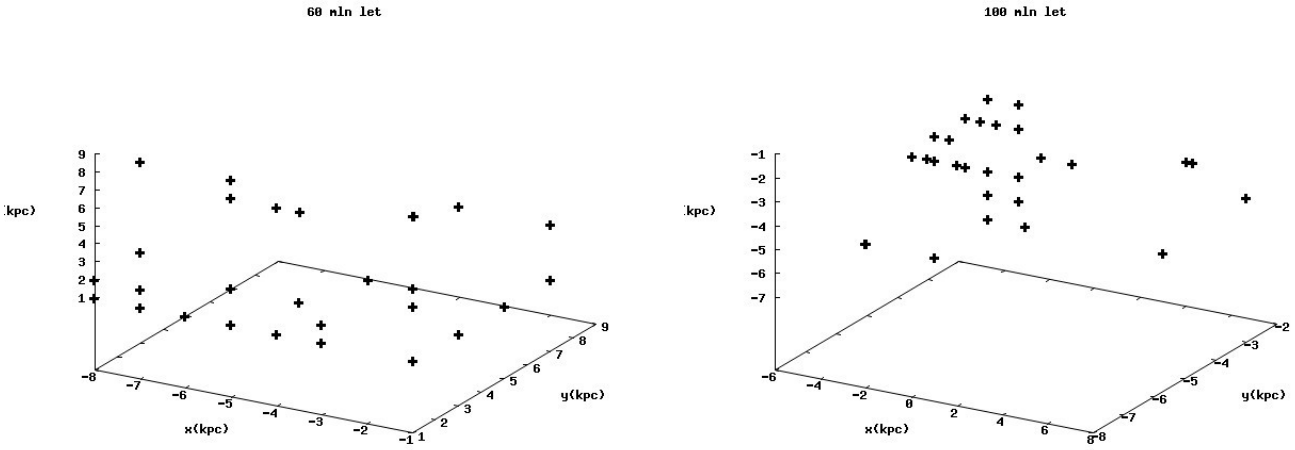

Fig. 2 The open cluster's positions of the Gould belt at the moments of time 60 and 100 mln.years