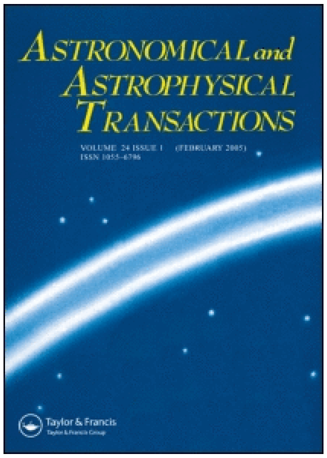

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THE ORBITS OF MOVING CLUSTERS IN THE GALAXY†

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The orbits of 12 moving clusters are studied in the framework of the Galaxy model of Kutuzov and Ossipkov (1989). The orbits have box-like forms in the meridional plane. The lifetimes of the moving clusters are estimated. A hypothesis of trapping by periodic orbits is proposed for the moving clusters.

KEY WORDS Galaxy models, moving clusters, orbits

Observations show that many stars in the solar neighbourhood belong to moving clusters since they have similar space velocities. Agekian and Orlov (1984) have distinguished nine moving clusters that contain about 13% of the stars from the "Catalogue of Nearby Stars" of Gliese (1969). Orlov and Yatsevich (1994) have revealed 12 moving clusters from the new Catalogue of Gliese and Jahreiss (1991). Agekian and Belozerova (1979) proposed to consider the moving clusters as dynamically stable coronae of the open clusters. These coronae can exist during a long time after the disruption of the cores of open clusters due to dynamical escapes.

On the other side, one can consider the moving clusters as stellar groups whose orbits fill tubes around some periodic orbits in the galactic potential. The role of stable periodic orbits as the "trappers" of such tube-like orbits was noted by Contopoulos and Magnenat (1985). In conservative systems, in particular in dynamical galactic models under consideration, the processes of "trapping" are certainly impossible. However the trapping may exist if the dissipation is included. In the Galaxy, the dynamical friction may play the role of such dissipative process. We have estimated the dynamical friction on stars, open clusters, and giant molecular clouds (GMC) using the Chandrasekhar formula. Some crude estimations show that the most effective friction is on the GMC.

The aim of this paper is to determine the orbits of moving clusters in the Galaxy model of Kutuzov and Ossipkov (1989) and to estimate the typical destruction time

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of the moving clusters under the external galactic field. This time determines a "vitality" of the moving clusters to be formed as a result of the disruption of the open clusters.

The central solution in the model of Kutuzov and Ossipkov (1989) is chosen for the investigation. The solar circle radius R_0 and the local circular velocity θ_0 are: $R_0 = 8.23$ kpc and $\theta_0 = 226$ km/s. The following values for the local galactic parameters are assumed: the solar z-coordinate $z_0 = 15$ pc; the solar space velocities with respect to the local standard of rest (LSR) are $U_0 = +8$, $V_0 = +12$, $W_0 = +7$ km/s along the directions to the Galaxy center, galactic rotation, and the Northern Galactic Pole, respectively.

The orbits of the stars of the moving clusters are studied in the meridional plane (R, z). A numerical integration of the equations of motion is carried out by the Runge-Kutta-Fehlberg 5(6)th order method. The evolution was traced during 10^9 years to the past. It appears that the orbits of the moving clusters have box-like forms.

Let us estimate a typical lifetime for the moving clusters in the tidal field of the Galaxy. In order to make these estimations, one chooses three stars (one of them is the principal star) in each cluster. We integrate the equations of motion simultaneously for each pair of stars and determine a time t_d when the spatial separation between the stars exceeds the assumed critical value r_c. Then averaging by three pairs is carried out for each moving cluster. The averages $\langle t_d \rangle$ are calculated for five adopted values r_c= 100, 200, 400, 800, and 1600 pc. For a typical velocity dispersion $\simeq$ 5 km/s, the stars of moving clusters diverge up to r_c =100 pc during $\langle t_d \rangle \simeq 2 \cdot 10^7$ years and up to r_c = 800 pc during $\langle t_d \rangle \simeq 4 \cdot 10^8$ years. According to these estimates, the Sirius and Hyades superclusters (age $\simeq 5 \cdot 10^8$ years, the observed velocity dispersions 2–6 km/s) would "dissolve" in the galactic field, unless they move along stable periodic orbits in the galactic potential or/and are the parts of the large-scale stellar flows with typical sizes $\geq$ 1 kpc.

Let us note that if the hypothesis of trapping is correct, then the "antipodes", i.e. the groups moving along the same periodic orbits in the opposite directions may be observed. Amongst these 12 moving clusters there are 3 pairs of antipodes. As a rule, the antipode clusters contain not so many stars as others. Therefore these clusters can be formed by trapping, and others may be the coronae of open star clusters. May be, both mechanisms (the destruction of open clusters followed by trapping of corona stars) are required for the formation of the moving clusters.

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DISCUSSION

Ossipkov: Have you studied how your moving clusters move in the equatorial plane $z = 0$? The orbit that is periodic in the meridional plane may correspond to a non-periodic three-dimensional orbit.
Müllări: We have not studied the projections of the orbits on the plane $z = 0$. Indeed, we integrate three-dimensional equations of motion. However, the analysis of periodicity in the 3D case is more difficult than in the projection on the meridional plane. We think that the effect of trapping is significant even for the orbits which projections on the meridional plane are periodic.
Surdin: Is the dynamical friction the main dissipative process in your calculations? How do you solve the problem of a short lifetime of individual GMC's in your calculations?
Müllări: Dynamical friction is the only dissipative factor under consideration. We do not use any concrete model of GMC's distribution and evolution. We have estimated the coefficient of dynamical friction for the GMC system in the solar neighbourhood and used the Chandrasekhar formula.