# ORBITAL ELEMENTS OF DIFFERENT GALACTIC POPULATION OBJECTS

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## 1. Introduction

The study of prevalent orbits in galactic subsystems can help us understand galactic structure and clarify its history. The classical analysis of flat orbits and metallicities of old stars led Eggen *et al.* (1962) to formulate the rapid collapse of the primordial Galaxy. On the other side Yoshii & Saio (1979) studied three-dimensional orbits that separate in spherical coordinates. They found the Galaxy contracted quasi-stationary after the formation of halo objects. Here we shall briefly discuss the results of numerical orbit calculations (with Merson's method) for selected galactic subsystems. The axially symmetrical two-component model of the Galaxy (Kutuzov, Ossipkov 1989) was adopted. One-component models (Barkhatova et al. 1987, Kutuzov 1988) were used also but no significant difference in orbit elements was found (Kutuzov & Ossipkov 1992). Pericenter and apocenter distances, $R_p$ and $R_a$, and the maximal height of objects over the galactic plane, $z_m$, were used as orbit elements as well as dimensionless quantities $e = (R_a - R_p)/(R_a + R_p)$ (eccentricity) and $c = 2z_m/(R_a - R_p)$ (the flatness of box filled by orbit projection on the meridional plane).

## 2. Results

**Open clusters:** This part of the work was initiated by late Prof. Barkhatova and some preliminary results were already published (Barkhatova et al. 1987). Orbits of 82 clusters were calculated. Heliocentric distances of clusters were taken according to Barkhatova's short "scale" (based on Kholopov's ZAMS), Hagen's "long" scale and some others. Corresponding changes of dimensionless elements (mainly $c$) were found to be small. All orbits were box ones. The average values of $e$, $c$ are equal to 0.07, 0.50 respectively. Of all possible correlations of orbital elements and physical characteristics of clusters (mass, age, metallicity), the only significant turned out to be the correlation of $e$ and [Fe/H]; the corresponding coefficient was equal to 0.65.

**Orbits of globular clusters:** The necessary data only for 13 cluster are available. Proper motions are taken from Cudworth (1974), earlier works of Meurers and Hallermann, Gamaley and others. Cluster distances and radial velocities were taken from Webbink and Hesser et al. As a rule the orbits were found to be almost hyperbolic (the cluster energy was positive for 5 from 11 clusters studied by Meurers and Hallermann). Most of the finite orbits are probably not box orbits and resemble the complicated figures found by Hayli (1965) and Innanen (1966). Possible ergodicity has no significance during the galactic lifetime. It seems that there is a week tendency of $R_p$ to increase with [Fe/H] in the interval from -1 to 0.



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**Planetary nebulae:** Data for the 49 most studied nebulae were used for the first orbit calculations. Proper motions and radial velocities ware taken from Cudworth (1974) and Perek & Kohoutek (1967) respectively. They used the "short" distance scale of Khromov (1985) with distances close to Sklovsky's ones (all orbits were found to be box orbits) and the "long" kinematical distance scale of Cudworth (1974) (one orbit was hyperbolic, two were probably tube orbits). The distributions of orbital elements $e$, $z_m$ are multimodal. Maybe this shows that our sample is not homogeneous. The average values of $e$, $c$, $z_m$ are equal to $(0.1 - 0.2)$, $(0.7 - 0.9)$ and $(0.7 - 0.9)$kpc respectively.

**Short-periodic cepheids:** We compiled data on proper motions and radial velocities of ca. 200 stars but the systematization of the material is necessary. At present we found orbits for 76 stars. Proper motions and radial velocities were taken according to Hemenway (1975); data of Clube et al. (1971) and some others were also used. Heliocentric distances were taken from Woolley et al. (1965).
We found that not only stars with retrogade motion but stars with hyperbolic or practically hyperbolic (the order of $R_a$ is some hundred kiloparsecs) orbits are not rare. Many orbits are probably tube orbits and it is difficult to find elements $e$, $c$ for them. The distributions of $e$, $z_m$, $R_p$ were studied. The presence of some maxima of the two last distributions is to be mentioned. The relations between orbital elements and type and period (for RR Lyrae stars) were studied. The portions of hyperbolic, retrogade and probable tube orbits increase with the period as well as average values of $e$ and $z_m$ (for stars with $P < 0^d.4$ average $e$, $z_m$ are 0.4 and 0.6 kpc and if $P > 0^d.6$ then the corresponding values are 0.6 and 0.7 kpc). Average $e$, $z_m$ are 0.7, 7 kpc for RR Lyrae stars. As for four "shortest" RR Lyrae stars we have found $e = 0.4$, $z_m = 1$ kpc.
The investigation of relation between elements and the Preston metallicity index $\Delta S$ show that stars with $\Delta S = 5.6$ have the largest eccentricity 0.6 and the largest average $z_m$ equal to 12 kpc.

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