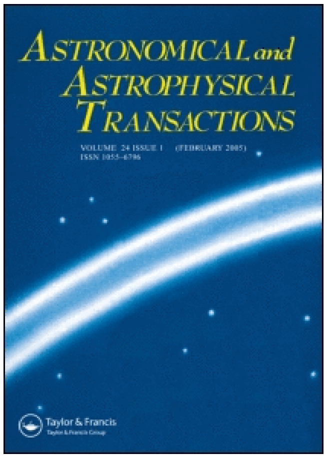

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Bok's problem analysis

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Bok's problem analysis

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The problem of the star cluster in the Galactic tidal field is briefly discussed. A sufficient condition for star escape is obtained.

Keywords: Cluster dynamics; Star escape

We shall consider the dynamics of a star cluster in a regular gravitational field of the Galaxy. The Galaxy will be considered to be stationary and to possess rotational and mirror symmetry. The orbit of a cluster is circular.

The movement of a trial star in a joint gravitation field of a cluster and the Galaxy is considered. The rotating rectangular system of coordinates is (x, y, z) with the origin at the centre of a cluster. The x axis is in the direction from the centre of the Galaxy, and the y axis is in the direction of movement of a cluster. The equations of movement of a star in this coordinate system are

$$\ddot{x} - 2\Omega_0 \dot{y} - \Omega_0^2 (R_0 + x) = \frac{\partial}{\partial x}(\Phi + \Phi_{\mathrm{g}}),$$

$$\ddot{y} + 2\Omega_0 \dot{x} - \Omega_0^2 y = \frac{\partial}{\partial y}(\Phi + \Phi_{\mathrm{g}}),$$

$$\ddot{z} = \frac{\partial}{\partial z}(\Phi + \Phi_{\mathrm{g}}),$$

here $\Phi(x, y, z)$ is the potential of a cluster and Ω_0 is the circular angular velocity at the cluster distance R_0 from the Galactic centre.

Bok [1] was apparently the first to consider this. The well-known Hill's problem can be considered as a special case of Bok's problem when the Galaxy and a cluster are dot weights.

Le us introduce dimensionless coordinates and time, $\xi = x/r_0$, $\eta = y/r_0$, $\zeta = z/r_0$ and $\tau = t/t_0$, assuming that $r_0 = (GM/\kappa_R^2)^{1/2}$ and $t_0 = \kappa_r^{-1}$, where G is the gravitational constant

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and M is the weight of a cluster. The equations of movement are transformed to a dimensionless kind:

$$\frac{\partial^2 \xi}{\partial \tau^2} - \gamma \frac{\partial \eta}{\partial \tau} = \frac{\partial \phi}{\partial \xi} + \xi,$$
$$\frac{\partial^2 \eta}{\partial \tau^2} + \gamma \frac{\partial \xi}{\partial \tau} = \frac{\partial \phi}{\partial \eta},$$
$$\frac{\partial^2 \zeta}{\partial \tau^2} = \frac{\partial \phi}{\partial \zeta} + \left(\frac{\kappa_R}{\kappa_Z}\right)^2 \zeta,$$

where γ is the dimensionless parameter describing the distinctive influence of external forces. In the vicinity of the Sun, $\gamma \approx 1.25$. $\phi = \phi(\xi, \eta, \zeta)$ is the dimensionless potential of a cluster.

In the case of an isolated cluster, there are criteria for a star to leave a cluster. So, it is possible for a star to leave a cluster when values of the integral of the energy of the considered star exceed some critical value $J > J^*$. For the Schuster–Plammer potential model the critical value of the dimensionless Jacobi constant depends on the parameter a of the model, $C = -3/2 + a^2/2$, and the dimensionless coordinates of the points of crossing by the Hill critical surface equal to $(\pm(1 - a^2)^{1/2}, 0, 0)$. In the case when the movement of a star is determined by both the field of a cluster and the field of the Galaxy, the criteria for a star to leave an isolated cluster are not always applicable. The star under the action of the field of the Galaxy can appear connected with a cluster while realizing the condition for it to leave an isolated cluster. The given problem was considered by Ross *et al.* [2]. Modelling a cluster as a dot weight, they found a sufficient condition for the escape of a star (it is understood that a star leaves a cluster when $r \to \infty$ at $t \to \infty$). Following their work, we obtain the same condition for the common form of a star cluster potential ($\phi(r) = \sum_{k=1}^{\infty} A_k/r^k$):

(i) $R_0 > 0$;
(ii) $X_0 Y_0 < 0$;
(iii) $\exists V > 0 : R \geqslant R_0 + Vt, \forall t > 0$.

Here, X_0, Y_0 are the coordinates of the guiding centre at $t = 0$.

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