

This article was downloaded by:[Bochkarev, N.]  
On: 4 December 2007  
Access Details: [subscription number 746126554]  
Publisher: Taylor & Francis  
Informa Ltd Registered in England and Wales Registered Number: 1072954  
Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



## Astronomical & Astrophysical Transactions

### The Journal of the Eurasian Astronomical Society

Publication details, including instructions for authors and subscription information:  
<http://www.informaworld.com/smpp/title~content=t713453505>

#### Bok's problem analysis

A. A. Davydenko <sup>a</sup>

<sup>a</sup> Department of Space Technologies and Applied Astroynamics, St Petersburg State University, Universitetskij Prospekt 35, Peterhof, St Petersburg, Russia

Online Publication Date: 01 April 2006

To cite this Article: Davydenko, A. A. (2006) 'Bok's problem analysis', *Astronomical & Astrophysical Transactions*, 25:2, 251 - 252

To link to this article: DOI: 10.1080/10556790600916749

URL: <http://dx.doi.org/10.1080/10556790600916749>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article maybe used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

## Bok's problem analysis

A. A. DAVYDENKO\*

Department of Space Technologies and Applied Astrodynamics, St Petersburg State University,  
Universitetskij Prospekt 35, Peterhof, St Petersburg 198504, Russia

(Received 3 July 2006)

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

$$\begin{aligned}\ddot{x} - 2\Omega_0\dot{y} - \Omega_0^2(R_0 + x) &= \frac{\partial}{\partial x}(\Phi + \Phi_g), \\ \ddot{y} + 2\Omega_0\dot{x} - \Omega_0^2y &= \frac{\partial}{\partial y}(\Phi + \Phi_g), \\ \ddot{z} &= \frac{\partial}{\partial z}(\Phi + \Phi_g),\end{aligned}$$

here  $\Phi(x, y, z)$  is the potential of a cluster and  $\Omega_0$  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.

Let 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

---

\*Email: AlexandrDavydenko@yandex.ru

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

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

where  $\gamma$  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–Plummer 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  $r \rightarrow \infty$  at  $t \rightarrow \infty$ ). 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)  $\exists V > 0 : R \geq R_0 + Vt, \forall t > 0$ .

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

## References

- [1] B.J. Bok, Harvard Circ. **384** 1 (1934).
- [2] D.J. Ross, A. Mennim and D.C. Heggie, Mon. Not. R. Astron. Soc. **284** 811 (1997).