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# GALACTIC TIDAL SHOCKS EFFECTS IN GLOBULAR CLUSTERS

Fidel Cruz and Luis Aguilar

Obs. Astronómico Nacional e Instituto de Astronomía, UNAM, Ensenada B. C., México

RESUMEN

Presentamos simulaciones de N–cuerpos de un modelo de King con $10^5$ partículas bajo un campo de marea galáctico. Los efectos de marea sobre un cúmulo estan dominados por dos procesos, diferenciados por como producen pérdida de masa en el sistema. Uno es desborde del lóbulo de Roche, que depende directamente del cociente de tamaños entre el cúmulo y el lóbulo de Roche. El segundo es el calentamiento de marea, que inyecta energía directamente en las órbitas de las estrellas en el cúmulo

ABSTRACT

We present results of a set of N–Body simulations of $10^5$–particle King models in the presence of a realistic Galactic tidal field. Tidal effects over a cluster are dominated by two processes, differentiated by the way they produce mass loss in the system. The first one is the Roche lobe overflow, which depends directly on the ratio of cluster to the Roche lobe size. The second process is tidal heating, produced by the time varying part of the Galactic tide, which injects energy directly on the orbits of the stars inside the cluster.

*Key Words:* **GALACTIC TIDAL FIELD: STATIC, DYNAMIC — GLOBULAR CLUSTERS: DESTRUCTION, EVOLUTION**

## 1. INTRODUCTION

Globular cluster evolution is mainly determined by 4 processes, which drive the cluster to its destruction. These processes are: Evaporation, by two–body relaxation (Spitzer & Chevalier 1973); Stellar evolution (Applegate 1986); Gravitational shocks, with the Galactic disk and the Galactic bulge (see Spitzer 1987); and dynamical fricction (Chandrasekhar 1942). Destruction by tidal shocks in the Galactic tidal field, is the most important procces for clusters with low concentration near the Galactic bulge (Aguilar, Hut & Ostriker 1988; Gnedin & Ostriker 1997; Murali & Weiberg 1997). This results came from semianalytical models, where destruction procceses take in an approximate way.

## 2. INITIAL CONDITIONS

We use self consistent models for the clusters; a King mass model with a concentration of 1.5, with $10^5$ particles, and initial mass of 5 $\times 10^5 M_{\odot}$. We chose 4 diferents sizes for the clusters (0.98, 1, 1.5, 3.5, in units of the Roche lobe at perigalacticon).

We choose three cluster orbits to have 3 perigalactic distances ($R_{peri}$ = 1.5 kcp, 3 kpc y 6 kpc) and with 3 eccentricities for each one ($e$= 0, 0.25, 0.5 y 0.75). The galactic potential is given by the Bachall, Schmit & Soneira (1983) model, with all components spherical. Our simulation span 10 orbital periods.

## 3. RESULTS

In Figure 1$a$ we show the time evolution for the energy and mass of a cluster in two experiments. In the top panels the cluster is 1.5 times the Roche lobe size at perigalacticon. This case is driven by is roche overflow. The lower panels present the case when cluster size is the same than your Roche lobe. In this case its the time

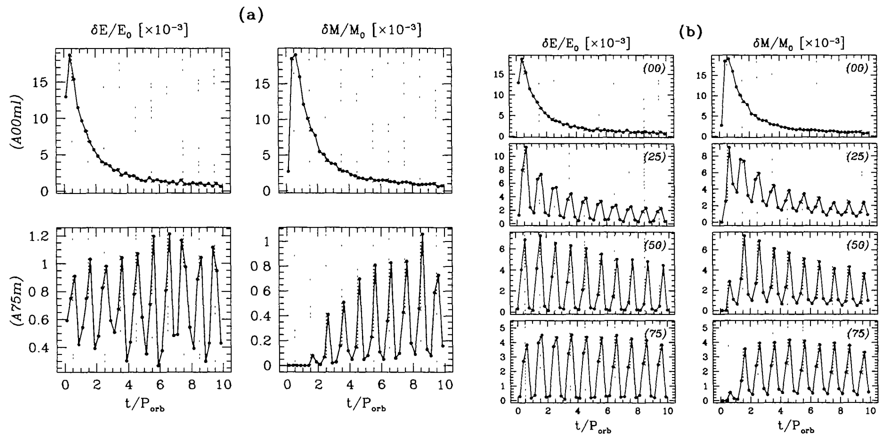


Fig. 1. In *(a)* comparison between two extreme cases of tidal effects on the binding energy (left panels) and mass (right panels) of a clusters: Roche lobe overflow (top panels) and tidal shocks (bottom panels). In *(b)* we present results for a series of experiments with increasing orbital eccentricity.

varying part of the galactic tidal field the one that dominates. In this case energy is injected to the cluster at each perigalactic passage.

In figure 1*b* we present results for a cluster 1.5 times bigger than the Roche lobe at perigalacticon. Four cases corresponding to different orbital eccentricities but the same perigalactica are presented. For the circular orbit (top panel), the evolution is driven mainly by the Roche overflow, whose effect diminishes as the cluster is shrinked to fit within the Roche lobe. For mild to medium eccentricities ($e$=0.25 and $e$=0.50, two middle panels). Roche lobe overflow decreases in importance, as the pulsed energy injection characteristic of tidal shocking apperars. For the most eccentric orbit ($e = 0.75$, bottom panel), tidal shocking seems to be the only significative effect. In this sequence, Roche lobe effects (which depend on the time-constant part of the galactic tidal field) decrease as the increasing orbit puts the cluster away form perigalacticon most of the time. On the other hand, this increases the the time-varying part of the tide, thus increasing the effect of tidal shocks.

## 4. SUMMARY

The global evolution of globular clusters driven by tidal shocks within a Galactic bulge is governed by two processes, differentiated by the way energy is injected to the cluster or the system losses mass:
- *Roche overflow* is result of tidal truncation imposed by the static part of the tidal field. The mass lost depends on the ratio between the clusters and the Roche lobe size.
- *Tidal heating* injects energy in the stellar orbits when the cluster aproaches the Galactic bulge. It depends on the time varying part of the galactic tide.
- Whereas *Roche overflow* is self-limiting and stops when the cluster is contained within the Roche lobe, *tidal heating* continues to pump energy into the cluster driving it to its distruption.

## REFERENCES

Aguilar, L., Hut, P., & Ostriker, J. P. 1988, ApJ, 335, 720.
Applegate, J. H., 1986, ApJ, 301, 132.
Bachall, J. N., Schmidt, M., Soneira, R. M. 1983, ApJ, 265, 730.
Chandrasekhar, S., 1942, Principes of Stellar Dynamics, (New York: Dover)
Gnedin, O., & Ostriker, J. P. 1997, ApJ, 474, 223.
Murali, C., & Weinberg, M. D. 1997, MNRAS, 288, 749.
Spitzer, L. & Chevalier, R. A. 1973, ApJ, 183, 565.
Spitzer, L. 1987, Dynamical Evolution of Globular Clusters, (Princenton: Princenton Univ. Press).