PRE-COLLAPSE EVOLUTION OF GALACTIC GLOBULAR CLUSTERS

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Abstract.

We investigated collisionless aspects of the early evolution of model star clusters. The effects of mass loss through stellar evolution and of a steady tidal field are modelled using N-body simulations. Our results (which depend on the assumed initial structure and the mass spectrum) agree qualitatively with those of Chernoff & Weinberg (1990), who used a Fokker-Planck model with a spherically symmetric tidal cutoff. For those systems which are disrupted, the lifetime to disruption generally exceeds that found by Chernoff & Weinberg, sometimes by as much as an order of magnitude.

1. Basic Concept

Recently, the focus of our interest has moved to the study of the evolution of more realistic models of globular clusters. For example, stars in a real globular cluster have different masses, and they change mass in response to their internal evolution. Moreover, most globular clusters exist within galaxies, and are influenced by the effects of the galactic tide.

These processes are linked. Each star (above the turnoff mass corresponding to the age of the system) loses a certain fraction of its mass near the end of its own evolution, and this process decreases the total mass of the cluster. Therefore the potential of the cluster weakens and the cluster expands. As a result some stars flow over the tidal boundary, and so further mass is lost by the cluster. The time scale of stellar evolution is $\sim 10^7$ years

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for a $10M_\odot$ star, which is roughly comparable to the dynamical time scale (or crossing time) of the cluster. If the cluster contains a large fraction of massive stars initially, the dynamics of the cluster is greatly affected by the mass loss due to stellar evolution.

Chernoff and Weinberg (1990; hereafter CW) investigated these and other aspects of the evolution of globular clusters using Fokker-Planck models. Their study included the following realistic effects: the spectrum of stellar masses, mass loss due to stellar evolution, and a tidal cutoff to model the effect of the galactic tidal field. They performed an extensive survey of models differing with regard to the initial mass function, the central potential of the cluster, and the galactocentric distance. For example, they obtained the result that the mass loss during 5×10^9 yr is sufficiently strong to disrupt weakly bound clusters with a Salpeter initial mass function.

The main purpose of the present paper is to check the results of CW using a model which should be an improvement in several respects. We use direct N-body calculations, which allow us to include processes taking place on the dynamical timescale. These are neglected by CW, who used an orbit-averaged method, and because the time scale for mass loss and the dynamical time are not well separated, it is not clear *a priori* that their approximation is justified. Like CW, we also include the following "realistic" effects: a spectrum of stellar masses, mass loss due to stellar evolution, and the tidal field of the galaxy. This last feature differs from CW's tidal cutoff, because it is not spherically symmetric, and also because it affects stars even while they remain inside the tidal radius. Like CW, we performed a survey of King models which differed in respect of the dimensionless central potential, W_0, the slope (α) of the initial stellar mass function (assumed to be a power law), and the galactocentric distance, R_g, of the cluster. In order to calculate the gravitational forces we used a special purpose computer for the gravitational N-body problem: GRAPE-3A (Okumura *et al.* 1993).

In general we obtained qualitatively similar results to those of CW: the less concentrated clusters ($W_0 \lesssim 4$) and/or ones that contained a greater proportion of massive stars initially ($\alpha \gtrsim -2.5$) are disrupted before reaching the stage at which core collapse can begin. The main quantitative difference is that the lifetime to disruption (for those clusters which do not survive until core collapse) may be much longer than that found by CW. For more details, see Fukushige and Heggie (1995).

References

Chernoff D. F., and Weinberg M. D., 1990, ApJ, 351, 121.
Fukushige, T., and Heggie, D. C., 1995, MNRAS, 276, 206.
Okumura, T., Makino, J., Ebisuzaki, T., Fukushige, T., Ito, T., Sugimoto D., Hashimoto, E., Tomida, K., and Miyakawa, N., 1993, PASJ, 45, 329.