THE EFFECTS OF STELLAR EVOLUTION AND GALACTIC TIDES ON GLOBULAR CLUSTER EVOLUTION

D. F. Chernoff, M. D. Weinberg and S. L. Shapiro

Cornell University

1. DESCRIPTION OF MODEL

We investigate the evolution of globular clusters in the Galactic tidal field prior to core collapse. These multimass models incorporate mass loss by stellar evolution.

The relaxation is simulated by the 1-dimensional (energy) Fokker-Planck equation. We assume the mass included by an $R_g = 8\,\mathrm{kpc}$ orbit produces the Galactic tide. The energy at the inner Lagrange point defines the tidal boundary. The number of stars in a given species is chosen according to a powerlaw IMF: the number of stars with mass between m and $m + dm$ is $\propto m^{-\beta}$. The 20 species used for these calculations have initial masses logarithmically spaced from 0.4 to 14.0 $M_\odot$. For purposes of modeling stellar evolution, we assume that mass is lost instantaneously from a star and the cluster at the end of its main-sequence lifetime leaving a 0.7 $M_\odot$ remnant. The main-sequence lifetime is taken to be $\tau_{ms} = 10\,\mathrm{Gyr}\,(m/M_\odot)^{-3}$. We intend to investigate a range of orbital radii and cluster concentrations. In all cases presented here, the cluster mass is initially distributed as a $W_0 = 3.0$ ($\log c = 0.672$) King model with $M = 10^5\,M_\odot$. The tidal radius is initially $R_{tidal} = 60\,\mathrm{pc}$. These parameters are summarized in Table I. For the IMF's considered, the stars with largest individual mass initially have the smallest density.

TABLE I

Initial conditions:

1). King Model with $W_0 = 3.0$ ($\log c = .672$), initial mass $10^5\,M_\odot$ and tidal radius 60 pc.
2). All models have 20 mass species, logarithmically spaced between 0.4 and 14 $M_\odot$, with equal velocity dispersions at t=0.
3). IMF of the form $n(m) \propto m^{-\beta}$.

Model	A.	B.	C.	D.
Mass spectrum	$\beta = 3.5$	$\beta = 3.5$	$\beta = 4.5$	$\beta = 3.5$
Galactic tide	yes	yes	yes	no
Stellar evolution (SE)	no	yes	yes	yes
Collapse time (Gyr)	6.2	47	62	137
Final mass ($M_\odot$)	9.0×10^4	1.1×10^4	2.2×10^4	8.5×10^4
SE mass loss ($M_\odot$)	0.0	1.4×10^4	5.2×10^3	1.4×10^4

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The Harlow-Shapley Symposium on Globular Cluster Systems in Galaxies, 673–674.

2. PRELIMINARY RESULTS

In case A (no stellar mass loss) relaxation is the main physical effect. The different species segregate by mass and the heaviest stars dominate the subsequent collapse. Due to mass segration the lightest stars are lost in the greatest number to the Galactic tidal field.

In cases B-D (with stellar mass loss), heating due to work done in ejecting the gas from the cluster controls the early evolution. The central potentials of the cluster initially decrease. Much later, relaxation dominates the evolution. However, the range in mass per star for the evolved components is small once the core collapse begins and there is no significant mass segregation. The collapse is morphologically similar to a single component model.

3. SUMMARY AND PLANS FOR FUTURE WORK

The main findings from cases A-D are:

1). We find that the lowest mass stars are significantly depleted in number due to mass segration in the presence of a tidal field. The $0.4\,M_{\odot}$ stars decreased by 95% in number in case B.

2). Stellar evolution narrows the range of stellar masses and decreases the extent of mass segration.

3). The cluster may lose up to 90% of its initial mass for an IMF powerlaw index of $\beta = 3.5$. This suggests that a proto-cluster must have a much larger initial mass or a much higher concentration.

4). The heating due to stellar evolution dramatically increases the core collapse time, perhaps exceeding the Hubble time. A larger initial mass will probably exagerate this effect. Given the sensitivity of the collapse time to the IMF and the remnant distribution, more detailed stellar evolution scenarios will be investigated.

A parameter survey in M, β, cluster concentration and R_g is underway.

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