DYNAMICS OF COLLAPSING SHELLS

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Introduction

In the last decade several scenarios for the formation of globular clusters have been suggested. One of these models starts with an OB-association exploding near the center of a molecular cloud (Brown et al., ApJ **376**, 115 (1991)): The expanding shell sweeps up the cloud material and later the expansion will be decelerated or stopped by the external pressure of the ambient hot gas. The shell itself can break into fragments and form stars. If the total energy of these stars is negative, they will recollapse and eventually form a bound system. According to this idea the dynamics of a thin stellar shell has been studied.

Initial conditions and numerical scheme

Initially a unit mass was homogeneously distributed within the radial range [0.9,1.0]. The velocity dispersion of the $N = 10\,000\,(100\,000)$ equal mass particles was chosen to give a virial coefficient $\eta_{\rm vir} = 0.05$. The softening parameter ϵ was set to 0.05. A smaller softening $\epsilon = 0.01$ did not change the results, whereas a larger value of $\epsilon = 0.1$ leads to a more spherical configuration. The equations of motion were integrated with a leap-frog scheme using a fixed timestep $\Delta t = 0.005$. This gives an energy conservation of typically 0.1-0.2% over the whole integration time. All simulations were performed with the direct summation on a GRAPE3 board.

Results

The dynamics of the shell shows three stages. During the first stage ($t < \tau_{\rm ff}(\rho_{\rm sh})$) the shell is slowly contracting and small inhomogeneities start to grow (Fig. 1 upper right). Already in this early stage the particles in the shell are strongly mixed because of the radially *decreasing* (global) free-fall time in the shell. In the second phase ($\tau_{\rm ff}(\rho_{\rm sh}) < t < 1 - 2\tau_{\rm ff}(\text{shell})$) these clumps become bound subsystems (Fig. 1 lower left), which merge after the shell's free-fall time $\tau_{\rm ff}(\text{shell}) = 1.59$ that is 40% larger compared to the collapse of a sphere with the same mass and outer initial radius.

P. Hut and J. Makino (eds.), Dynamical Evolution of Star Clusters, 399–400.

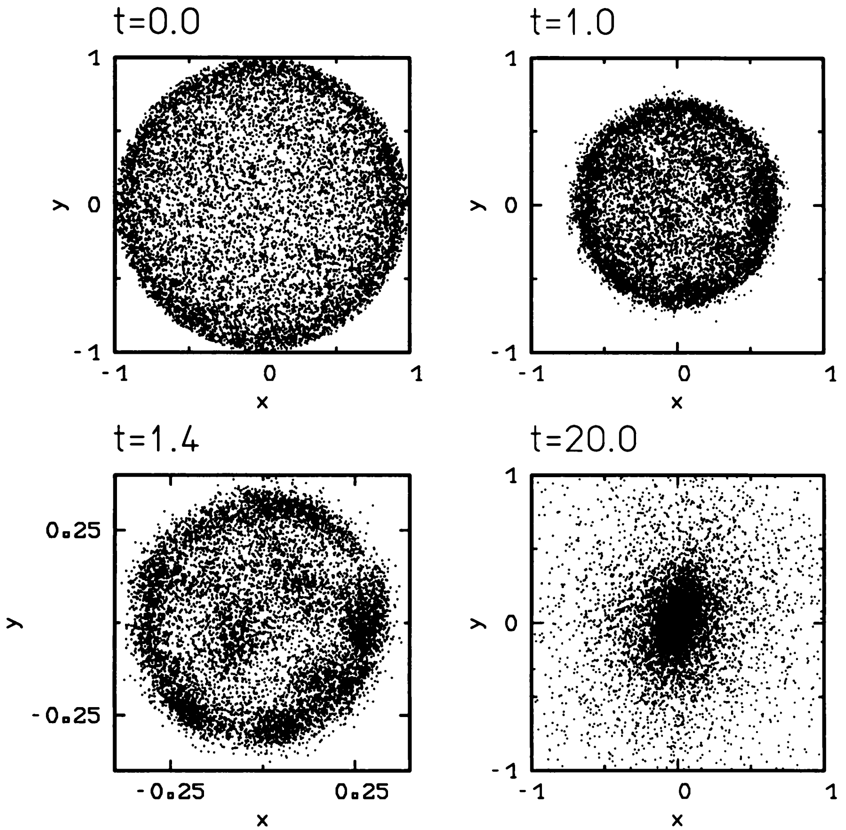

Figure 1. Projections of the collapsing shell on the x-y plane at different times: a) during the collapse (t=0.0, 1.0, 1.4) and b) after reaching an equilibrium state (t=20.0).

Finally, a radially anisotropic triaxial system has been formed (Fig. 1 lower right). The mass-loss of 8% is by a factor of 3.5 smaller than for spheres whereas the anisotropy $1-\sigma_\theta^2/\sigma_r^2$ is reduced by 0.15. Additionally, the half-mass radius is increased by 50% and the 90%-radius is a factor of 6 smaller compared to collapsing spheres. Therefore, *violent relaxation seems to be less efficient for collapsing shells.*

From the simulations one can conclude that the resulting ellipticity is significant larger for collapsing shells than for spheres. Hence, the shape of young clusters might be used to check the scenario of collapsing shells.

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