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Single collapse of spherical stellar systems

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We have studied the collapse of spherical stellar models and their structure after violent relaxation. The numerical method is a phase space method based on the splitting scheme. This method enabled us to reproduce the evolution of cold models having virial ratios as small as $\sim 10^{-2}$, with high accuracy. We have examined the following models:

Uniform sphere: $\rho = 3M/(4\pi R_0^3)$ $r<R_0$,
$\rho \propto r^{-0.5}$ model: $\rho = 5M/(8\pi R_0^3)\ (r/R_0)^{-0.5}$ $r<R_0$,
$\rho \propto r^{-1}$ model: $\rho = M/(2\pi R_0^3)\ (r/R_0)^{-1}$ $r<R_0$,
$\rho \propto r^{-2}$ model: $\rho = M/(4\pi R_0^3)\ (r/R_0)^{-2}$ $r<R_0$,
Cooled Plummer model: $\rho = 3M/(4\pi R_0^3)\ [1 + (r/R_0)^2\ ]^{-2.5}$,

We chose the radius of the models, R_0, as $R_0 = \beta^{-1}$ in non dimensional units, where M is the total mass, and β is the initial virial ratio. This gives the phase space density that is independent of β. Every initial model except for the cooled Plummer model has the constant velocity dispersion. For the cooled Plummer model, we simply reduced the velocity dispersion of the equilibrium model by a factor.

We can summarize the numerical results as follows:
(1) Uniform sphere
This model collapses violently because all parts of the initial model have the same collapse time. As a result, a large amount of stars gain energy and escape from the system. The collapse forms a dense core where the phase space desity remains close to its initial value. Thus, the core structure is determined mainly by the phase space density, and it is almost independent of the initial virial ratio (or the intial radius).
(2) Power-law models
The collapse is mild and the relaxation takes place as phase mixing as matter in the outer region infalls. The density profile within the half-mass radius can be approximated by $\rho \propto r^{-2.2}$. This profile is universal: it depends on neither the initial virial ratio nor the power-law index. The radial velocity dispersion overcomes the tangential one, and the value remain almost constant in this region (figure 1). This is consistent with the index of the density profile (–2.2).
(3) Cooled Plummer model
The collapse resembles that of a uniform sphere when the virial ratio is large, though no escapers appear: the collapse stops soon and a massive core and a steep envelope form. On the other hand, the collapse of a cold model results in a less massive core and a less steep envelope, like that of power-law models.

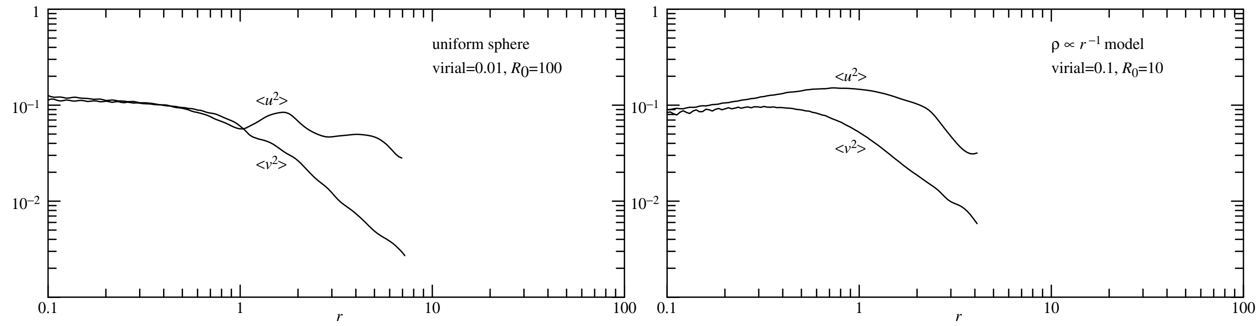

Figure 1. Velocity dispersions after collapse, for a uniform sphere and a $\rho \propto r^{-1}$ model.

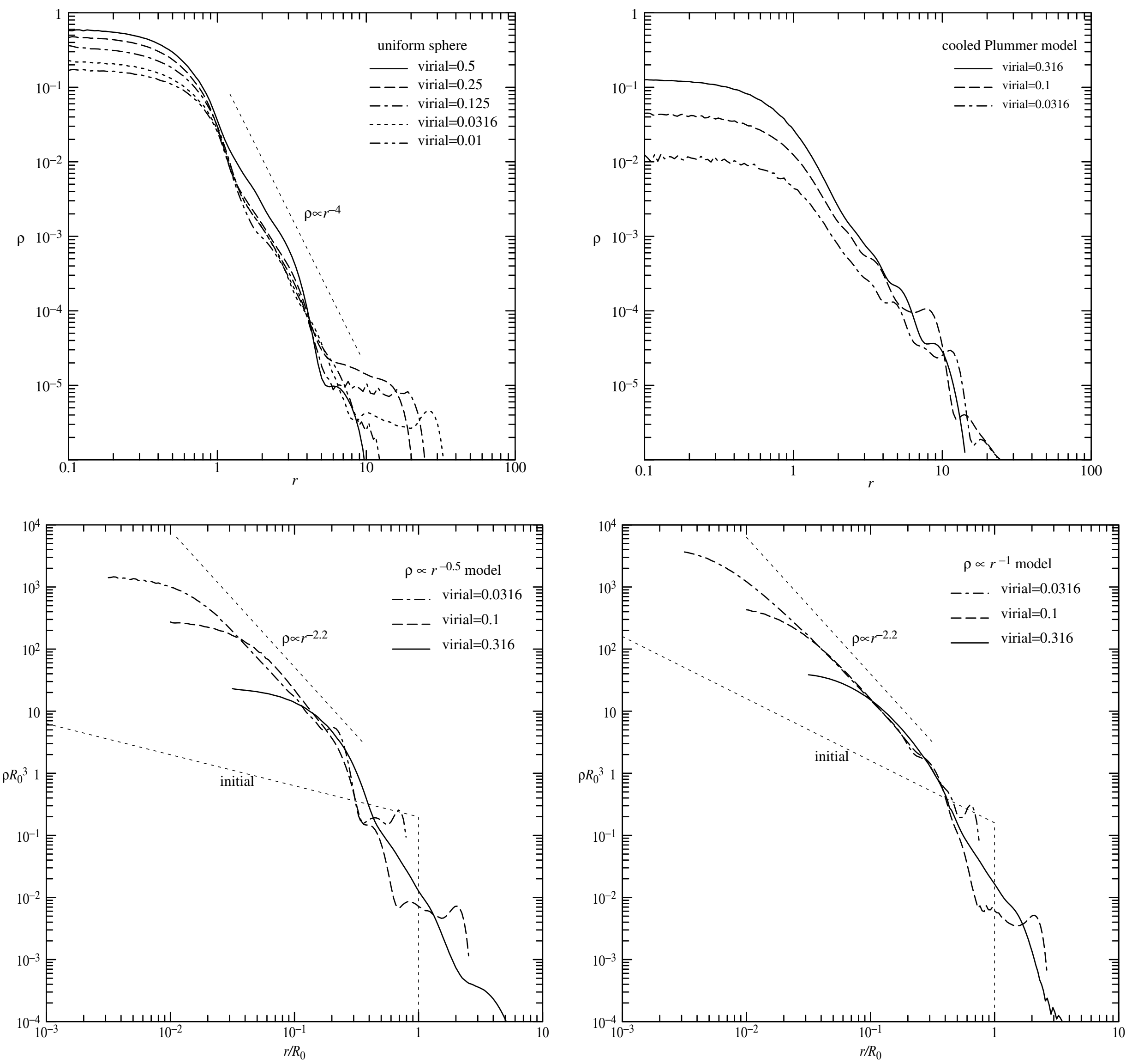

Figure 2. Density profiles of spherical models after collapse. Every model has the initial radius given by $R_0 = \beta^{-1}$, where β is the initial virial ratio. Note that the figures for power-law models are scaled so that models have the same initial density profile.