Gravitational Collapse: Free-falling Cloud

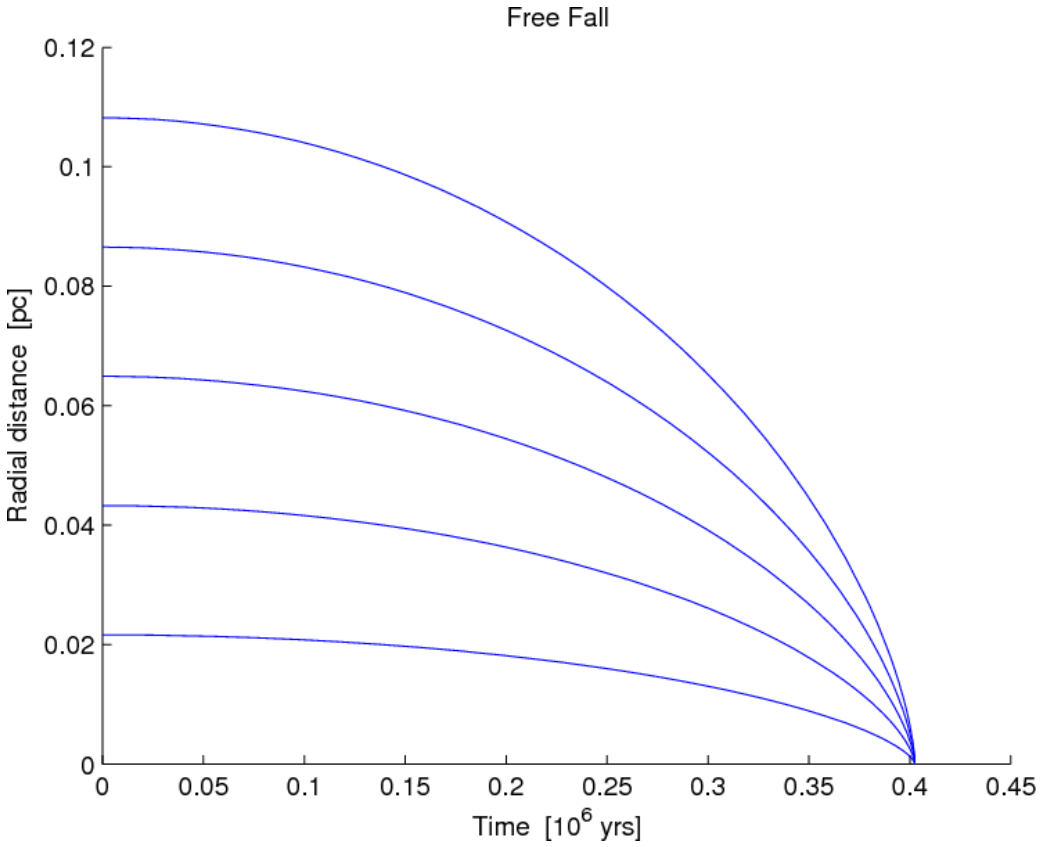
The **MATLAB routine *FreeFall.m*** tracks selected layers of a dense **molecular cloud core** which is **collapsing under its own gravity** (cloud mass exceeds the Jeans mass), assuming that thermal pressure and forces other than gravity can be neglected (free fall collapse). The **equation of motion in the co-moving frame of references** (see lecture) can be reformulated as two coupled first-order ordinary differential equations (ODEs, defined in the file ***track_ff.m***), i.e.,

$$\frac{dr}{dt} = u \qquad \frac{du}{dt} = -\frac{G m_r}{r^2}$$

describing the **evolution of radial distance *r(t)* and velocity *u(t)***, where m_r **denotes the part of the mass of the spherical cloud contained within radius *r***. Using an ODE solver provided by MATLAB, the motion of the free-falling layers is computed and plotted for typical conditions in a dense cloud core (probable site of star formation). In addition to the standard scenario of a **homogeneous cloud**, several **simple radial density profiles** can be chosen, where the matter is more concentrated towards the center of the cloud.

Homework (due May 3, 2010):

- First, run the routine ***FreeFall.m*** without any modifications and **check that the result looks like the included figure**. Pre-selected type of density profile: constant (*i_rho = 0*). Note: the file ***track_ff.m*** containing the definition of the ODEs should be in the same folder.
- Make **additional runs with the other density profiles**: *i_rho = 1* (density ~ $1/r$), *i_rho = 2* (density ~ $1/r^2$) and *i_rho = 3* (density ~ $1/r^3$)
  (note: all profiles have the same total cloud mass *M_cloud*)
- **Describe how and explain why the tracks differ for the available choices of the density profile**. How does the gravitational acceleration vary with radial distance for the different profiles? Could the different outcomes of this "race" of the free-falling layers be predicted by **looking at the formula for the free fall time**?
- Hand in (email: Susanne.Hoefner@fysast.uu.se, preferably in pdf format) the resulting **plots together with a short text describing and explaining the differences** between the original version (see included figure) and the other three choices of *i_rho*.



Movement of selected layers in a dense molecular cloud core collapsing under its own gravity (free fall collapse) obtained with the unmodified routine *FreeFall.m* (homogeneous density).