March 21

Initial conditions for the turbulent molecular cloud run

Inner radius

The density profile follows an $r^{-3/2}$ power law. To avoid a singularity at the center, an interpolation is done over a radius. This inner radius is defined in the parameter file. It should follow the prescription of a singular isothermal sphere (see Binney & Tremaine p.305), which is also the definition of the King radius:

$$r_0 \equiv \sqrt{\frac{9\sigma^2}{4\pi G\rho_0}} \tag{1}$$

where σ is the velocity dispersion and could be estimated as $\sigma = \mathcal{M}c_s$, where $c_s = \sqrt{\gamma P/\rho} = \sqrt{\gamma k_B T/\mu}$ is the sound speed.

The isothermal sound speed in our simulation was estimated

$$c_s = \sqrt{\frac{k_b T}{\mu m_p}} \tag{2}$$

I'm unsure why a factor of γ was not included. For 30 K, this gives a sound speed of about 34000 cm/s or 0.34 km/s. At a Mach number of 5, this gives a supersonic dispersion of $\sigma = 1.7$ km/s

This gives an inner radius of $r_0 \approx 1.595\text{e}17$.

Rotation

Set the same ratio of rotational to gravitational energy β as in Peters et al. 2010a. According to Goodman et al. (1993), this is given by (see equation 6):

$$\beta = \frac{1}{4\pi G\rho_0}\omega^2 \tag{3}$$

In practice we can probably use the central density ρ_c instead of determining an average density ρ_0. Looking at the numbers from other simulations, we could use an ω of 1.3e-14.

The link to the Goodman et al. (1993) paper:
`http://adsabs.harvard.edu/cgi-bin/bib_query?1993ApJ...406..528G`

We want to complete our simulation with a similar β to check if disks form in the turbulent environment.

The ω necessary to produce a $\beta = 0.05$ would be

$$\omega = \sqrt{4\pi G\rho_0\beta} \approx 7.15 \times 10^{-13} \tag{4}$$

using $\rho_0 = \rho_c = 1.22 \times 10^{-17}$.

After testing this, however, I found that the rotation was much too fast. Perhaps using $\rho_0 = \rho_c$ was not a very good assumption at all, since ρ_c is orders of magnitude larger than the average. I wrote a little Python script that sums up all the mass inside the outer radius and divides it by the total volume, defined by the outer radius. In this case, for an outer radius of 5.97402×10^{18} cm and about 1000 $M_\odot$, we get an average density of 2.96415×10^{-21} g/cm^3, which gives us $\omega = 1.114 \times 10^{-14}$.