Graduate Course on Planet Formation
Assignment 1

Professor Hanno Rein

Due: 11am, Friday, October 9th

1D Viscous Accretion Disk Model

Write a 1D hydrodynamic code to evolve a viscous accretion disk. Write it in any language you like, but don't use any external libraries to solve the fluid equations. Your numerical scheme does not have to be unconditionally stable as long as it solves the test problem correctly.

Start with the following equations, corresponding to mass and angular momentum conservation:

$$\frac{\partial \Sigma}{\partial t} + \frac{1}{r}\frac{\partial}{\partial r}\left(\Sigma\, r\, v_r\right) = 0$$

$$v_r(r,t) = -\frac{3}{\Sigma\sqrt{r}}\frac{\partial}{\partial r}(\nu\Sigma\sqrt{r}).$$

Discretize the equations on an equidistant radial grid with $N = 200$ grid points. Stagger the radial velocity and surface density. Update the system in a leap-frog fashion, i.e. calculate the new surface density assuming a constant radial velocity, then update the radial velocity assuming a constant surface density. Don't worry about boundary conditions.

Test your implementation by reproducing the spreading of an infinitesimally thing ring (see lecture notes). Think about what *infinitesimally thin* means for a discretized system of equations.

Then, run your code with a more complicated initial density profile (i.e. multiple delta functions).