

ASSIGNMENT No. 9

DUE: Thursday, April 30

Reading: Read Maoz p. 58-61 on convection and 114-119 on Jeans instability

1. Convection in a disk

Consider a disk in vertical hydrostatic equilibrium around a star or black hole, such that the pressure gradient force balances the vertical gravitational force.

Show that the condition for convective instability to occur is

$$\frac{dT}{dz} < -\frac{(\gamma - 1)\mu}{\gamma k} z\Omega^2,$$

where $T(z)$ is the vertical temperature profile.

Show therefore that if the heating is centrally concentrated such that the temperature obeys $T = T_0(1 - z/H_T)$ near the midplane for some thermal scale height H_T , then a region near the midplane would become convectively unstable.

2. Jeans masses and sizes

For the following ISM conditions, compute the Jeans length

$$L_J \equiv v_{th} \left(\frac{\pi}{G\rho} \right)^{1/2}$$

and Jeans mass

$$M_J \equiv \rho L_J^3 :$$

(a) the warm ISM, with $T = 8000$ K and $n = 0.3 \text{ cm}^{-3}$; (b) diffuse atomic hydrogen clouds with $T = 60$ K, $n = 40 \text{ cm}^{-3}$; (c) cold molecular clouds with $T = 10$ K, $n = 100 \text{ cm}^{-3}$; (d) dense molecular cores with $T = 10$ K, $n = 10^4 \text{ cm}^{-3}$;

Comment, based on the above, on where you would expect star formation to be located.