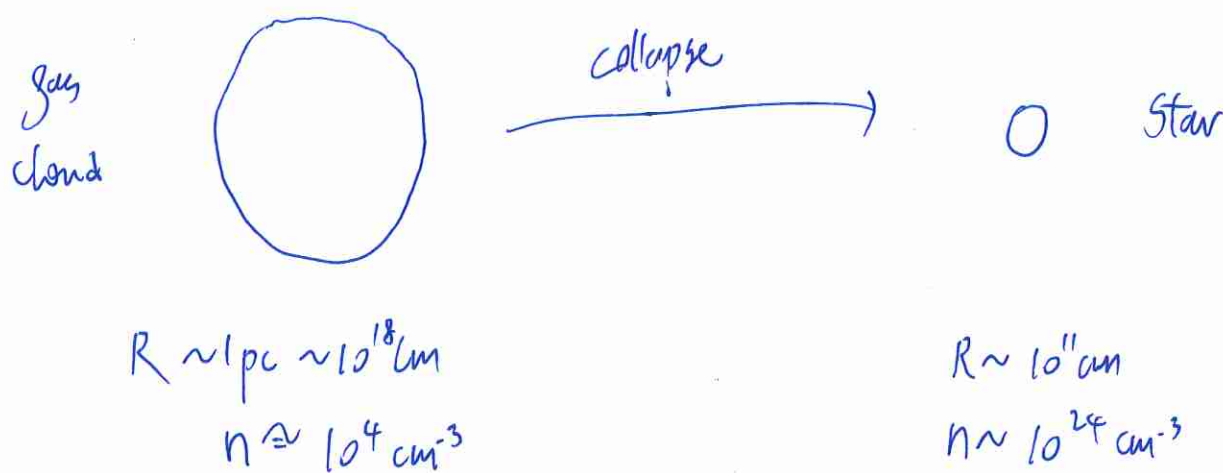


After learning about the growth of structure and the basis of radiative cooling, we will go ahead to learn about star formation.

4) Physics of star formation.

Intro: The 'miracle' of star formation.

We start with a gas cloud, and gravitational collapse have to squeeze it into much higher density.



→ Gravity needs to overwhelm all opposing forces over a huge range of scales.

• Gravitational Instability

03-08-2016

Note: We dealt with the collapse of DM; here, we consider gas ('baryons') only.

a.k.a. $\rightarrow$ self-gravity

Consider a region of the interstellar medium



Interstellar
medium (ISM)

Q: If the **cloud**, by chance, gets squeezed a bit, what will happen?

$\rightarrow$ continued collapse $\Rightarrow$ instability

OR

rebound $\Rightarrow$ stability

A: cloud can rebound if thermal pressure can push back quick enough! 03-08-2016

- The squeezing induces a pressure wave in the cloud, which travels with the speed of sound, c_s .

[A handy way to construct c_s :

recall $E_{kin} = \frac{1}{2} m v^2 \sim m v^2$

$$k_B T = m_H c_s^2$$

$$\Rightarrow c_s = \sqrt{\frac{k_B T}{m_H}} \propto T^{\frac{1}{2}}]$$

- The strength of gravity is reflected by the free-fall time:

$$t_{ff} \sim \sqrt{\frac{1}{G \rho}}$$

- The strength of the opposing pressure is reflected by the "sound crossing time"

$$t_{sound} = \frac{L}{c_s}$$

L : length scale of the system.

Condition for gravity to win
(i.e. gravitational instability).

03-08-2016

$$t_{\text{sound}} > t_{\text{ff}}$$

$$\Rightarrow L > L_J = \frac{c_s}{\sqrt{G\rho}} = \text{Jeans length.}$$

or

$$M_J = \frac{4}{3} \pi L_J^3 \cdot \rho \sim \rho \cdot L_J^3 \\ = \text{Jeans Mass}$$

$$\boxed{M_J \propto T^{3/2} \cdot \rho^{-1/2}}$$

$$M_J \cong 1 M_{\odot} \cdot \left(\frac{T}{10 \text{ K}} \right)^{3/2} \cdot \left(\frac{n}{10^5 \text{ cm}^{-3}} \right)^{-1/2}$$
