Universidad Nacional de Río Negro
Int Partículas, Astrofísica & Cosmología - 2020

- **Unidad** 02–Astrofísica, estrellas y planetas
- **Clase** U02 C02 - 6/16
- **Fecha** 09 Sep 2020
- **Cont** Fusión Estelar, 1
- **Cátedra** Asorey
- **Web** https://gitlab.com/asoreyh/unrn-ipac/

$$M = m - 5(\log_{10} d - 1)$$

$$\log_{10}\left(\frac{d}{10\,pc}\right)$$

Cuerpo negro a T y radio R

$$L = 4\pi\sigma R^2 T^4$$

cte de Stefan Boltzmann

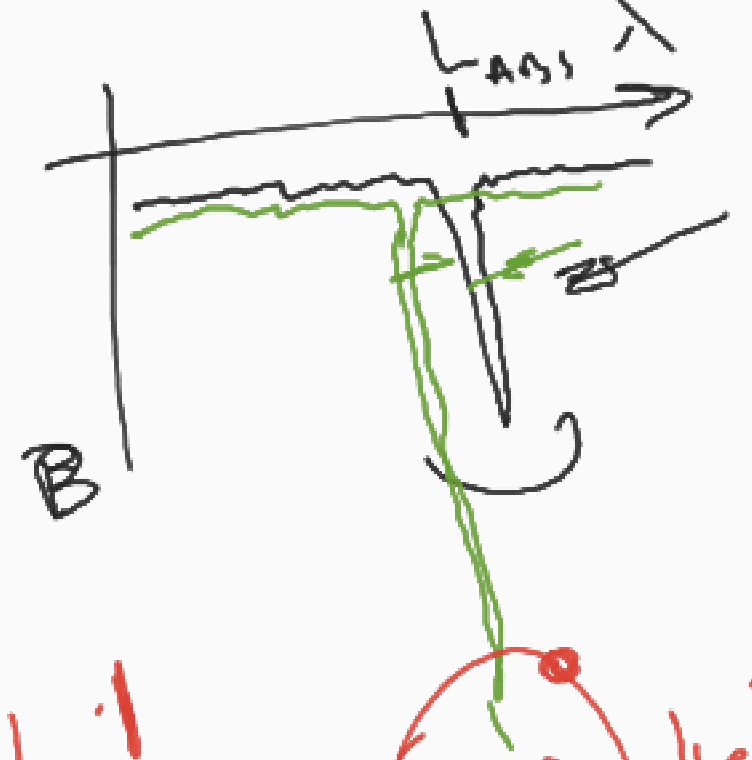
Ley de Stefan Boltzmann

$$\sigma = 5{,}67\times 10^{-8}\ \frac{W}{m^2 K^4}$$

$$\frac{\partial B}{\partial \lambda} = 0 \rightarrow \text{Extremo} \rightarrow \lambda_{max} = \frac{3\,mm\,K}{T}$$

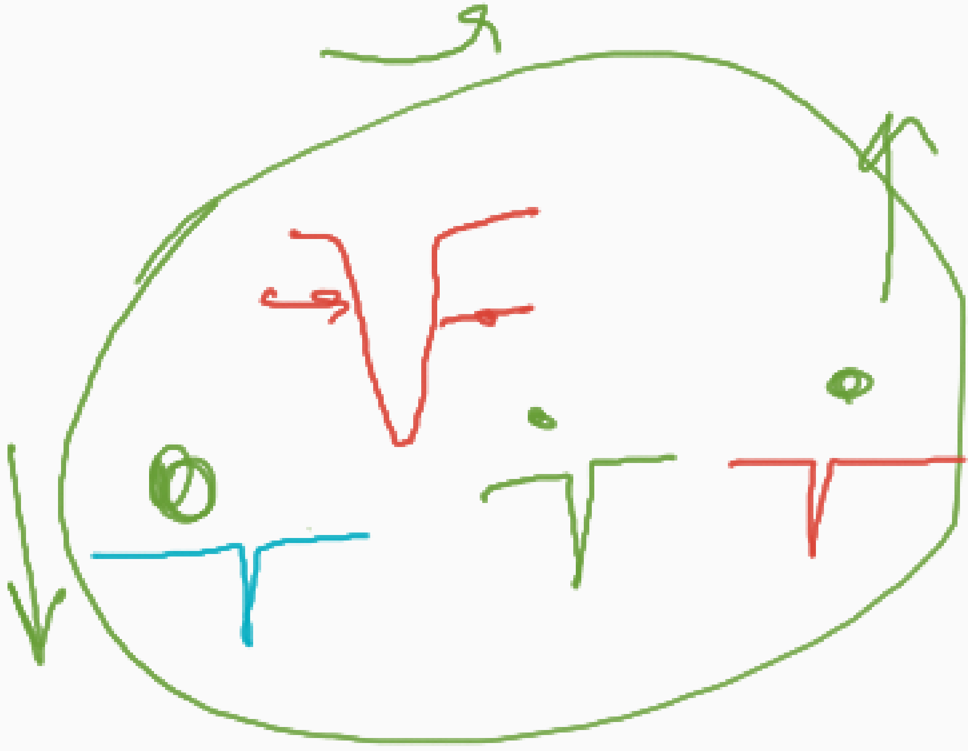
Infrarrojo

$$T = 3000K \Rightarrow \lambda_{max} = \frac{3\,mm\,K}{3000} = 10^{-6}\,m = 1\,\mu m = 1000\,nm$$



Linea de Absorción Espectral.

$^4He_2$



$$L = 4\pi\sigma R^2 T^4$$

$$L_{\odot} = 4\pi\sigma R_{\odot}^2 T_{\odot}^4$$

$$L_B = 4\pi\sigma R_B^2 T_B^4 = 135000\, L_{\odot}$$

$$L \propto R^2 T^4$$

$$T_{\odot} = 5700K$$

$$T_B = 3400K$$

$$\left(\frac{3400}{5700}\right)^4 = 1/7{,}8$$

$$\frac{L_B}{L_{\odot}} = \frac{\cancel{4\pi\sigma} R_B^2 T_B^4}{\cancel{4\pi\sigma} R_{\odot}^2 T_{\odot}^4} = \left(\frac{R_B}{R_{\odot}}\right)^2 \left(\frac{T_B}{T_{\odot}}\right)^4$$

$$135000 = \left(\frac{R_B}{R_{\odot}}\right)^2 \cdot \frac{1}{7{,}8}$$

$$1{,}053 \times 10^6 = \left(\frac{R_B}{R_{\odot}}\right)^2 \Rightarrow R_B \simeq 1000\, R_{\odot}$$

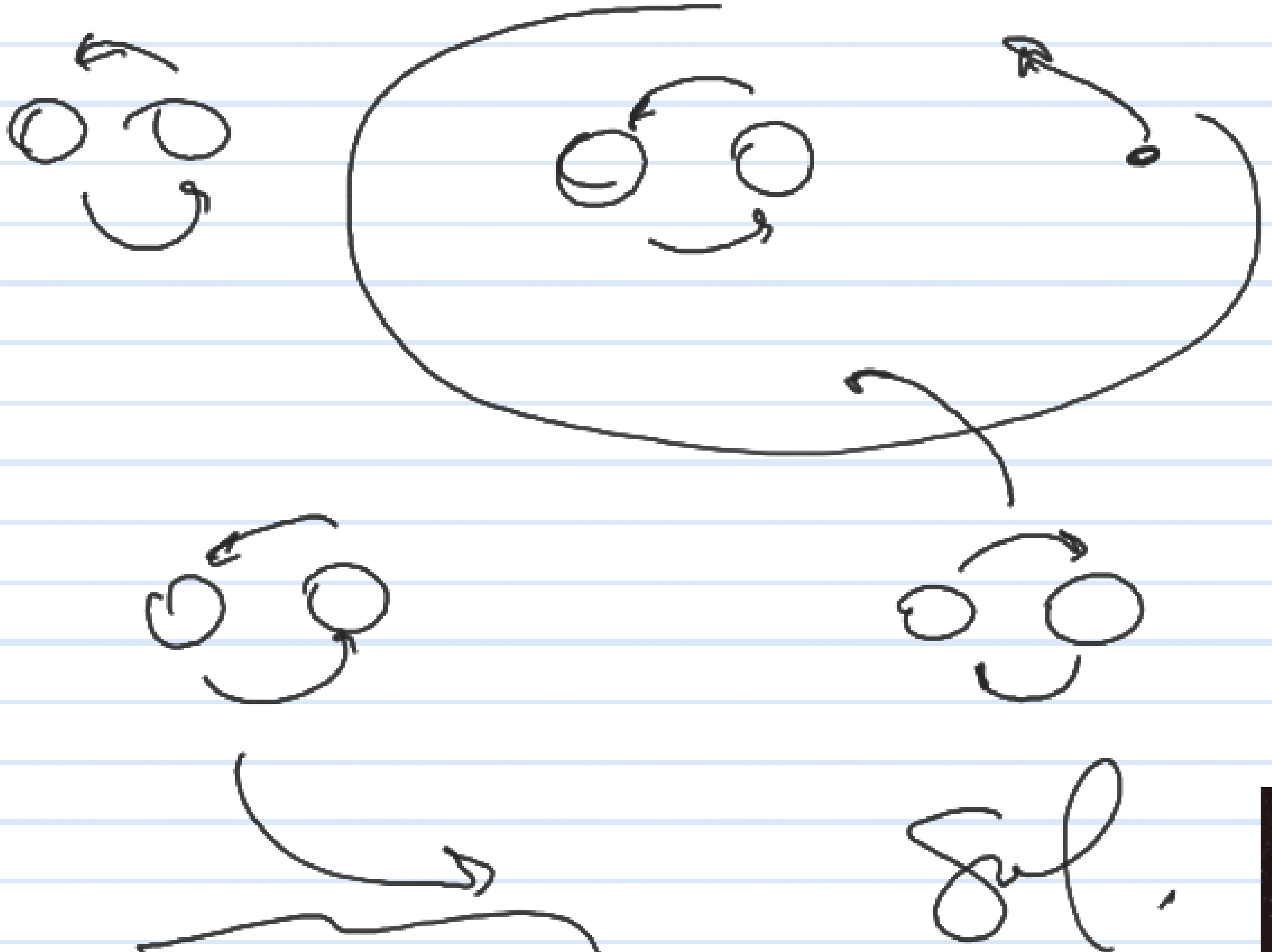
$R_{\odot} = 700\,000$ km.

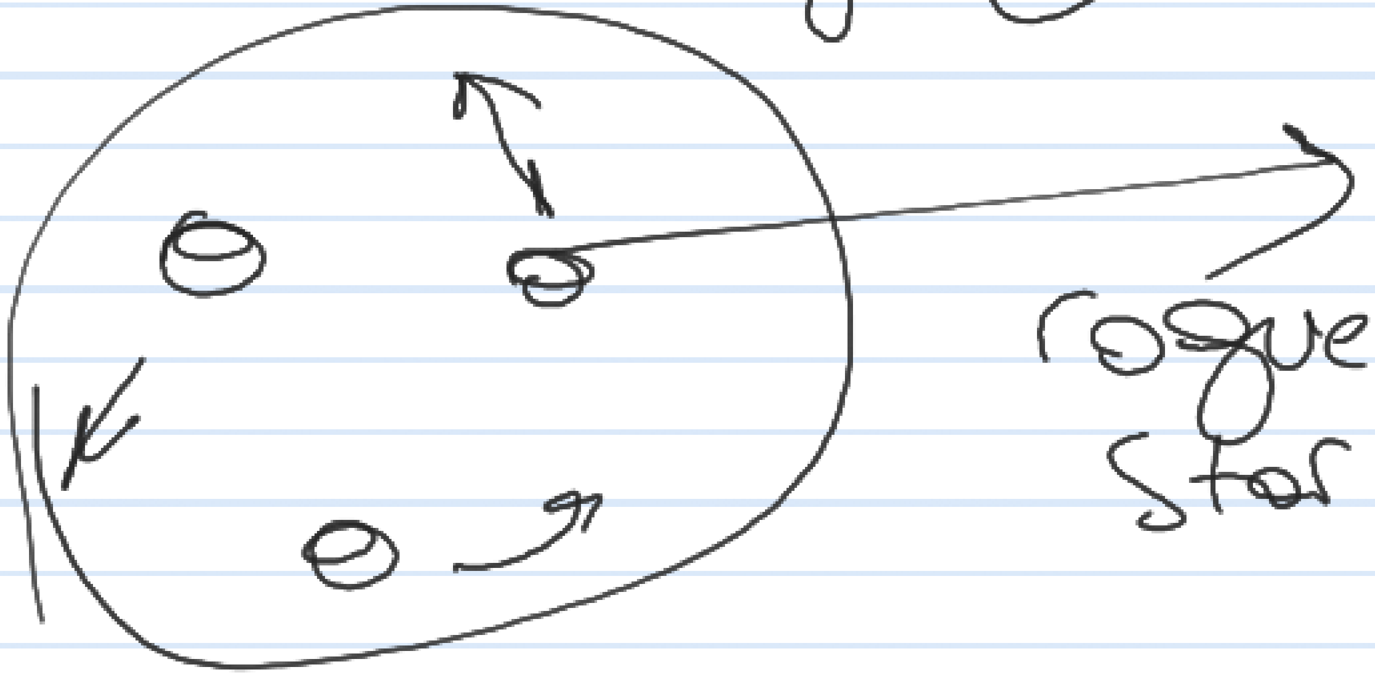
$R_B = 700\,000\,000$ km

$L \propto R^2 T^4 \Rightarrow R^2 \propto L/T^4 \quad 2\log R \propto \log L - 4\log T \Rightarrow \log R = \left(\frac{A}{2}\right)(\log L - 4\log T)$

$y \qquad m \qquad x$

$y = mx + b$





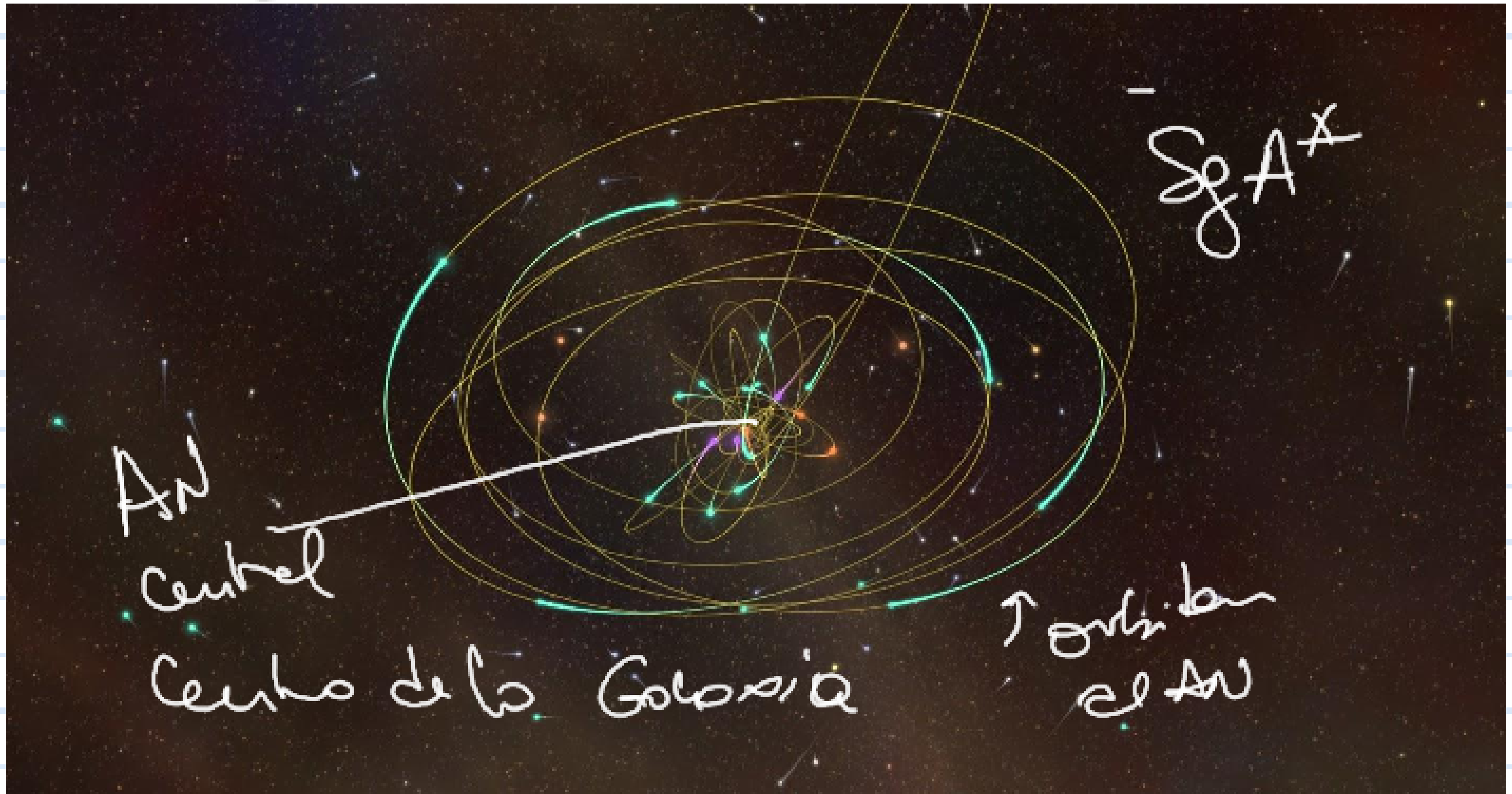
rogue star

⊙ Sol ⊕ Tierra

$E_G = \frac{GM^2}{R}$

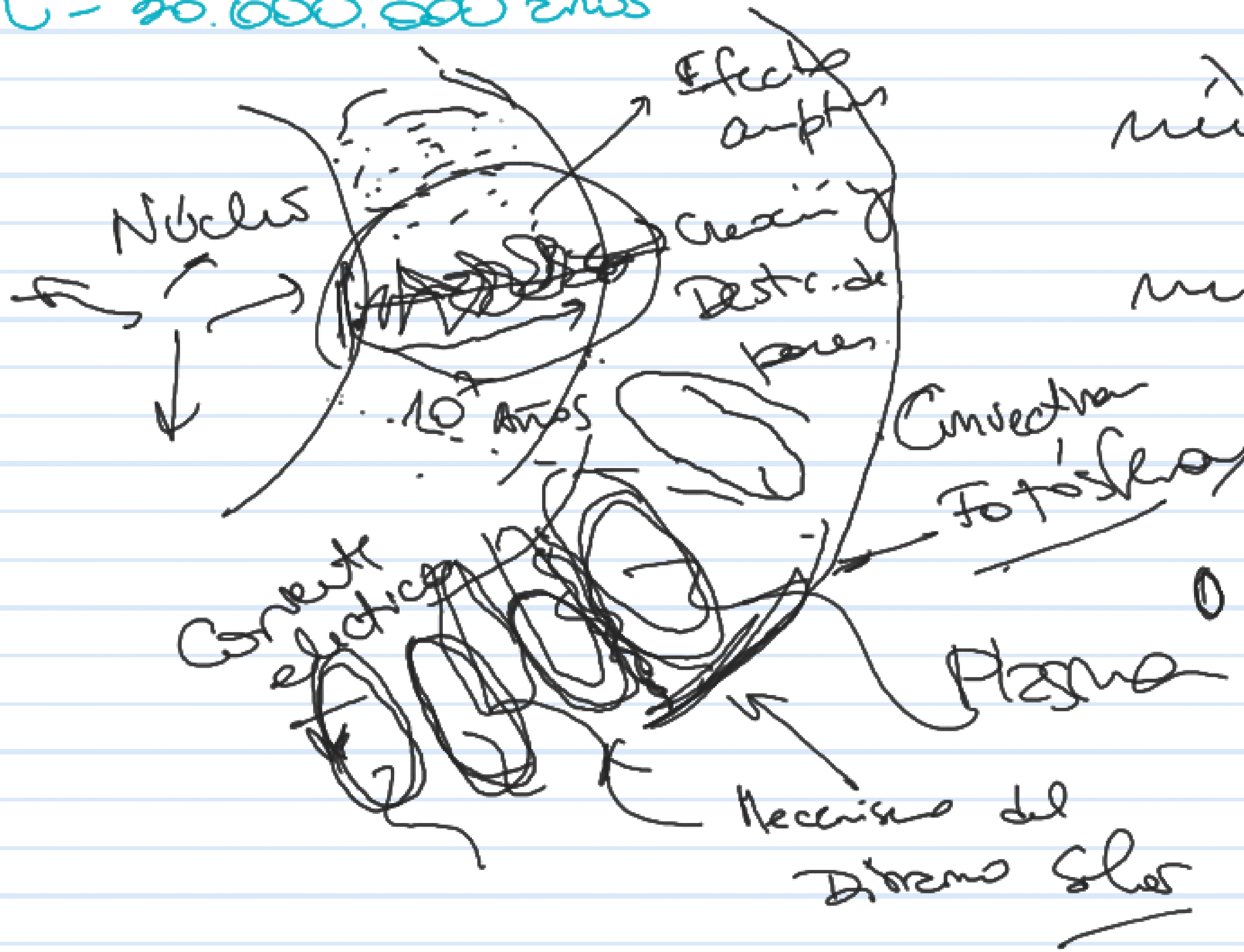
$E_G^{\odot} = \frac{G M_{\odot}^2}{R_{\odot}}$

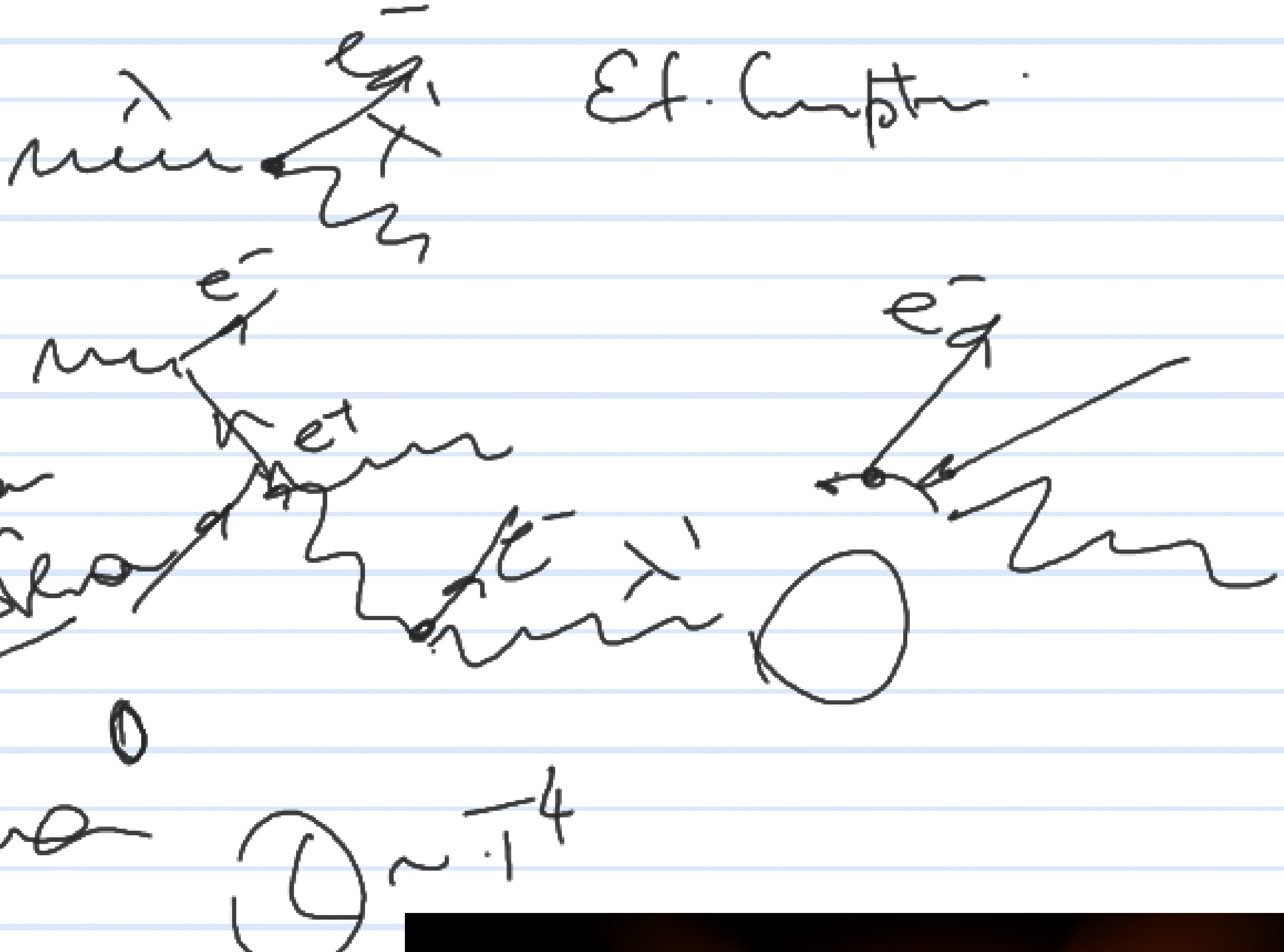
$E_{\odot} \approx 3.8 \times 10^{41}$ J

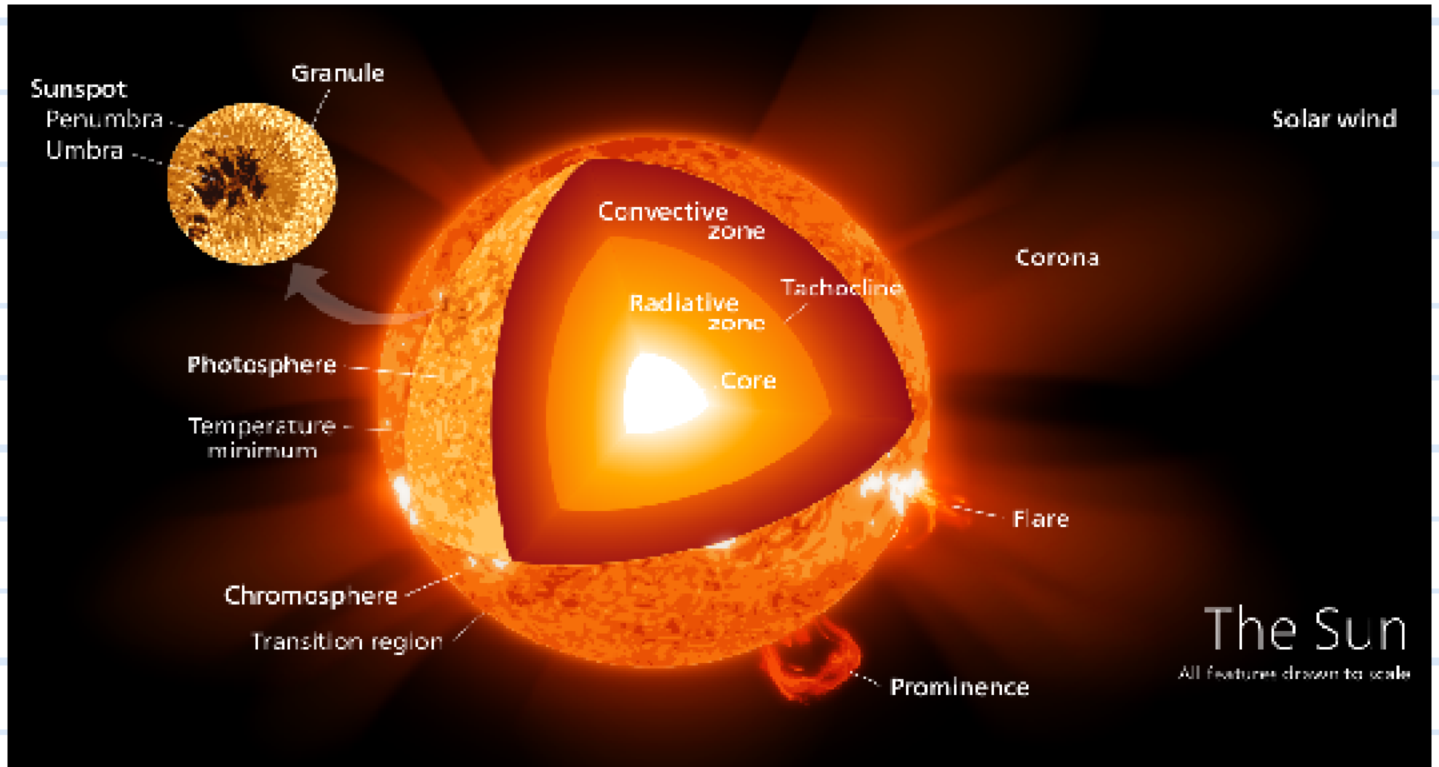


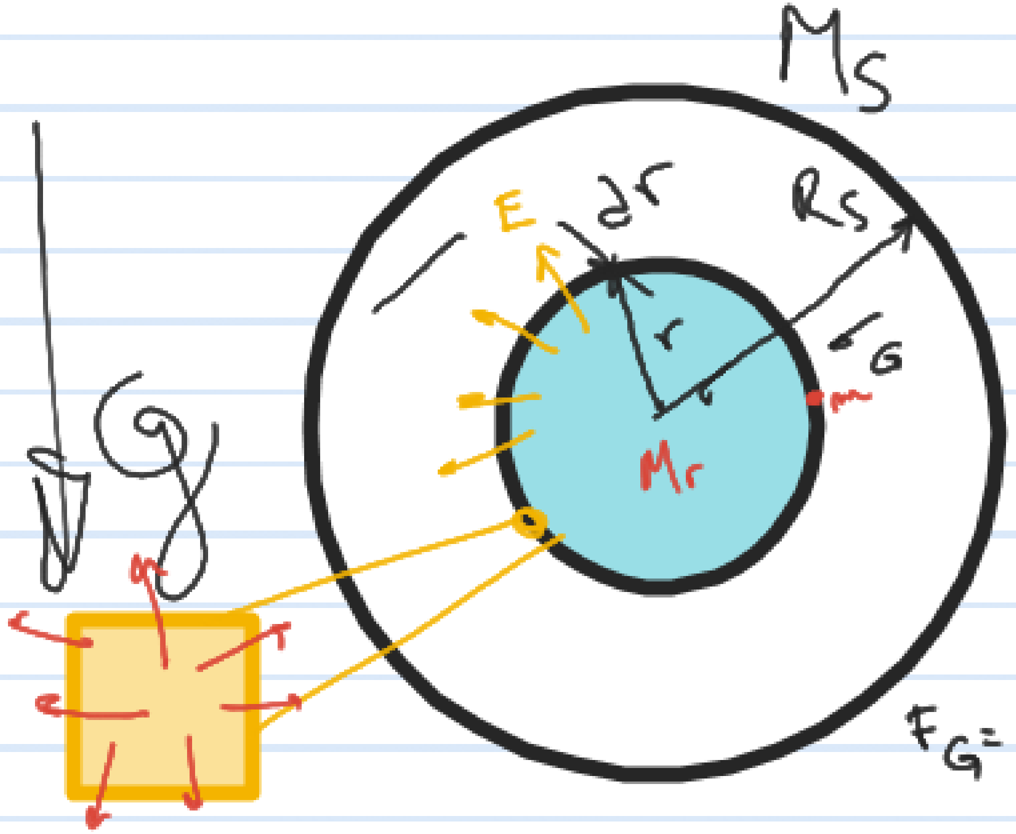
$$L_\odot \,;\, E_G^\odot \Rightarrow L = \frac{\Delta E}{\Delta t} \Rightarrow \Delta t = \frac{\Delta E}{L} \Rightarrow \tau_\odot \approx E_G/L = 9{,}9\times 10^{+14}\,s \simeq 3\times 10^{7}\text{ años}$$

$\tau \cong 30.000.000$ años









Conservación de la Energía

$$\epsilon = \frac{dE}{dm\,dt} \Rightarrow \epsilon\, dm = \frac{dE}{dt} = d l_r$$

$$d l_r = \epsilon\, dm \Rightarrow d l_r \overset{(1)}{=} \epsilon_r \overbrace{4\pi r^2 dr \rho_r}^{dm}$$

$$\boxed{d l_r = 4\pi \rho_r \epsilon_r r^2 dr} \quad (3)$$

Balance y Prod. de Energía

$$l_r(r+dr) = l_r + d l_r.$$

Conservación de la Energía

Teorema de Gauss

ρ_r $\qquad \vec{F}_r = -\frac{G M_r m}{r^2} \hat{r}$

$$dm = \underbrace{4\pi r^2 dr}_{dV} \rho_r$$

$$\boxed{dm = 4\pi r^2 \rho_r dr} \quad (1)$$

Ec. de Continuidad de la masa

$$F_G = -\frac{G M_r\, dm}{r^2} \Rightarrow \vec{F}_r = -\frac{G M_r}{r^2} 4\pi r^2 \rho_r dr \hat{r}$$

$$\vec{F}_p = p_r \cdot A \Rightarrow \vec{F}_p = 4\pi r^2 p_r \hat{r}$$

$$\cancel{4\pi r^2} dp = -\frac{G M_r}{r^2} \cancel{4\pi r^2} \rho_r dr$$

$$\boxed{dp = -\frac{G M_r \rho_r}{r^2} dr} \quad (2)$$

Equil. Hidrostático

q_r → flujo de Energía que atraviesa la cebolla

$[q] = \frac{[E]}{[A][t]} \Rightarrow l_r = A_r \cdot q_r$

$K = \frac{1}{\rho_r \cdot dr}$

$l_r = 4\pi r^2 q_r$ $\quad q_r = \sigma T_r^4$ $\quad L_r = A_r \sigma T_r^4$

$q_r = \frac{L_r}{A_r} = \sigma T_r^4$

$dq_r = \sigma\, d(T^4) = 4\sigma T^3 dT$

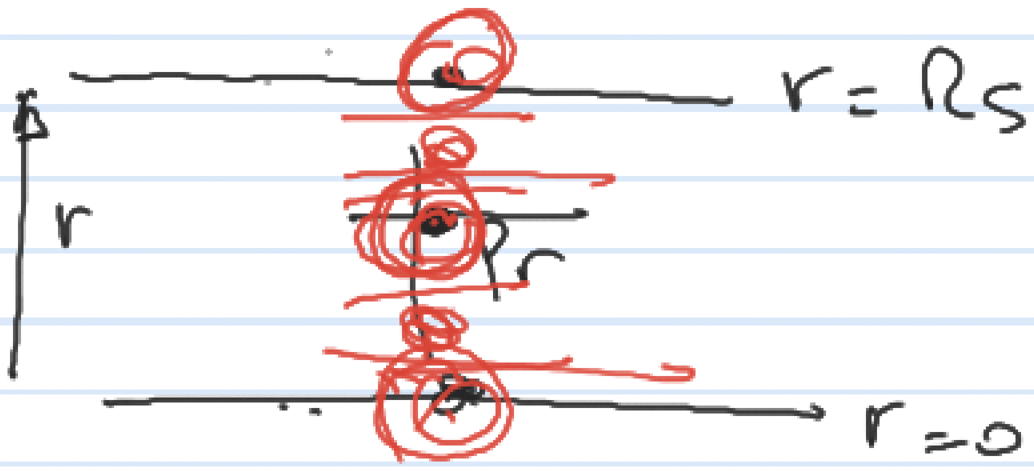
$dq = 4\sigma T_r^3 dT$ $\quad dq = -K q_r \rho_r dr \Rightarrow dq = -K_r q_r \rho_r dr$

$4\sigma T_r^3 dT = -\kappa q_r \rho_r dr$

$q_r = \frac{-4\sigma T_r^3}{\kappa_r \rho_r}\left(\frac{dT}{dr}\right)$ $\quad \frac{dT}{dr} < 0$

$l_r = 4\pi r^2 q_r \Rightarrow \boxed{l_r = \frac{-16\pi\sigma}{\kappa_r \rho_r} r^2 T_r^3 \frac{dT}{dr}}$ (4)

Ec. de transporte radiativo



$$d \rightarrow \Delta$$

$$\lim_{h \to 0} \frac{f(x+h) - f(x)}{h} = f'(x)$$

Δx

$$\frac{df}{dr} \rightarrow \frac{\Delta f}{\Delta r} = \frac{f_{i+1} - f_i}{r_{i+1} - r_i} = \frac{f_{R_s} - f_0}{R_s - 0}$$

Método de Diferencias finitas

$$dM_r \rightarrow \Delta M = M_{R_s} - M_0 = M_s - 0 = M_s$$

$$\rho_r \rightarrow \rho_r = \frac{\rho_{R_s} + \rho_0}{2} = \frac{0 + \rho_0}{2} = \rho_0/2$$

$$r^2 \rightarrow r_i^2 = \left(\frac{r_{R_s} + r_0}{2}\right)^2 = \left(\frac{R_s + 0}{2}\right)^2 = \frac{R_s^2}{4}$$