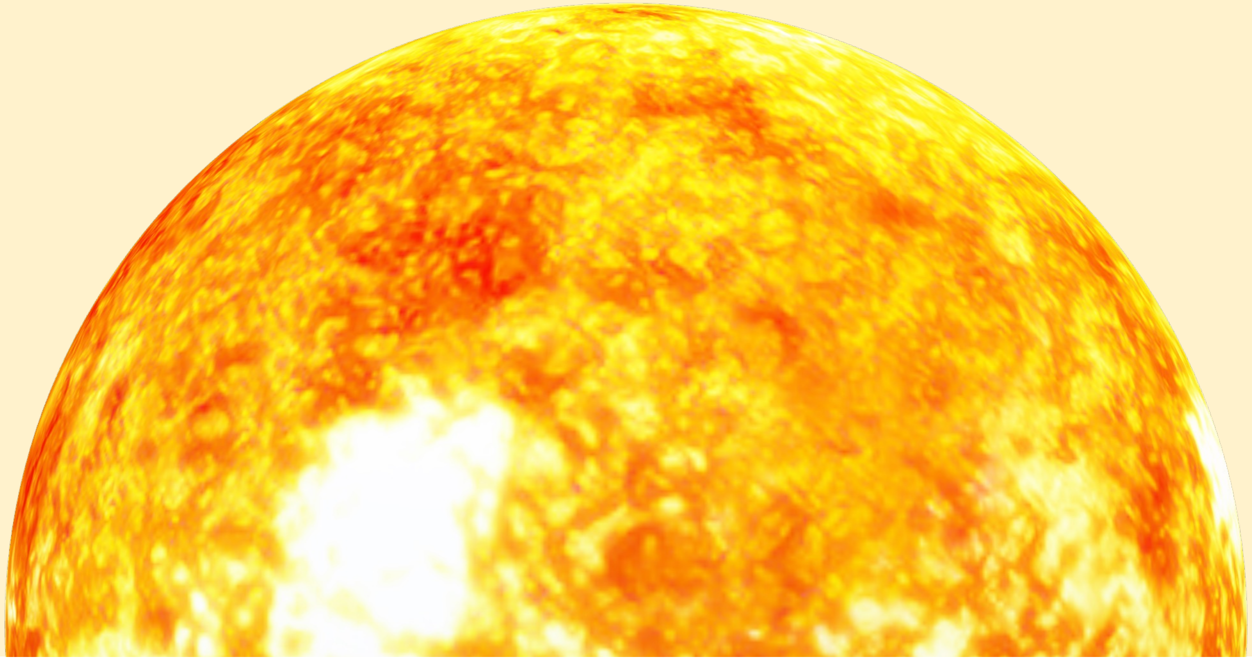
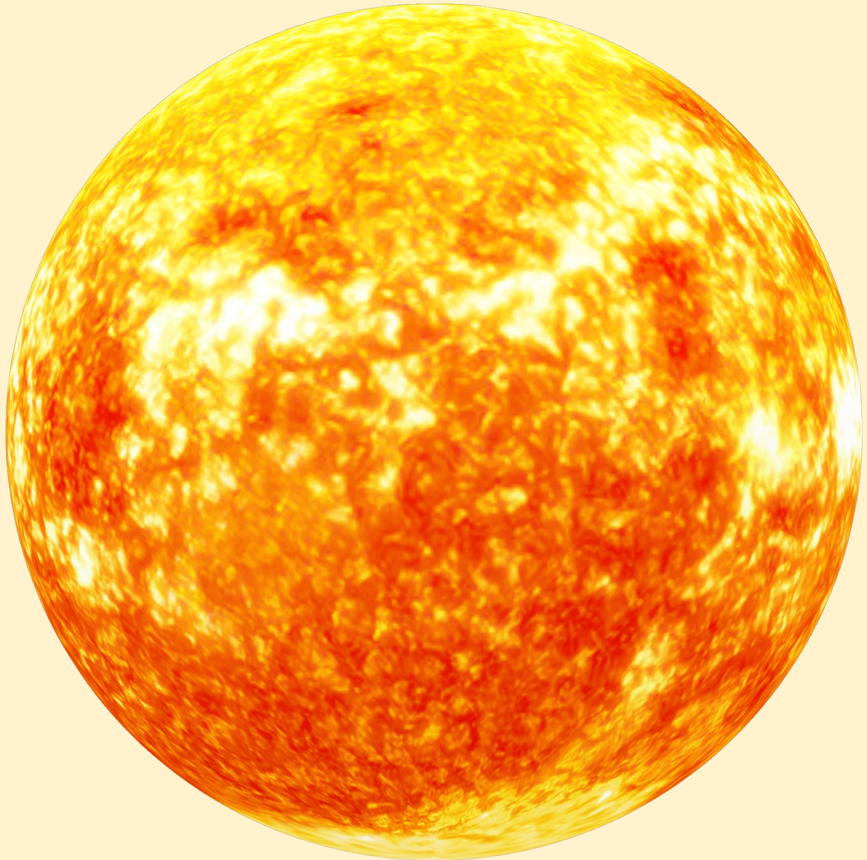
THE SUN

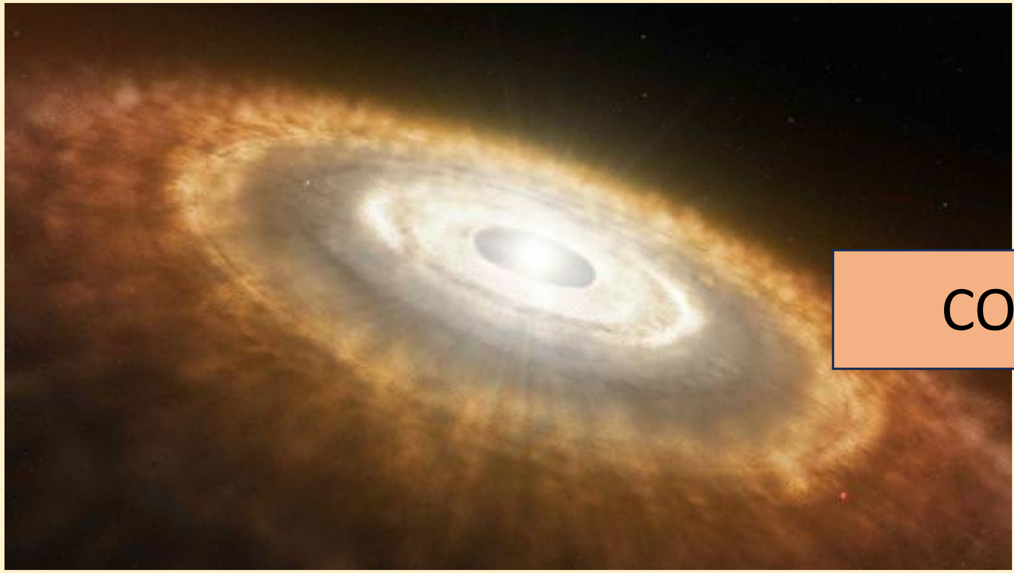
DAVID REDONDO MARTIN



INDEX

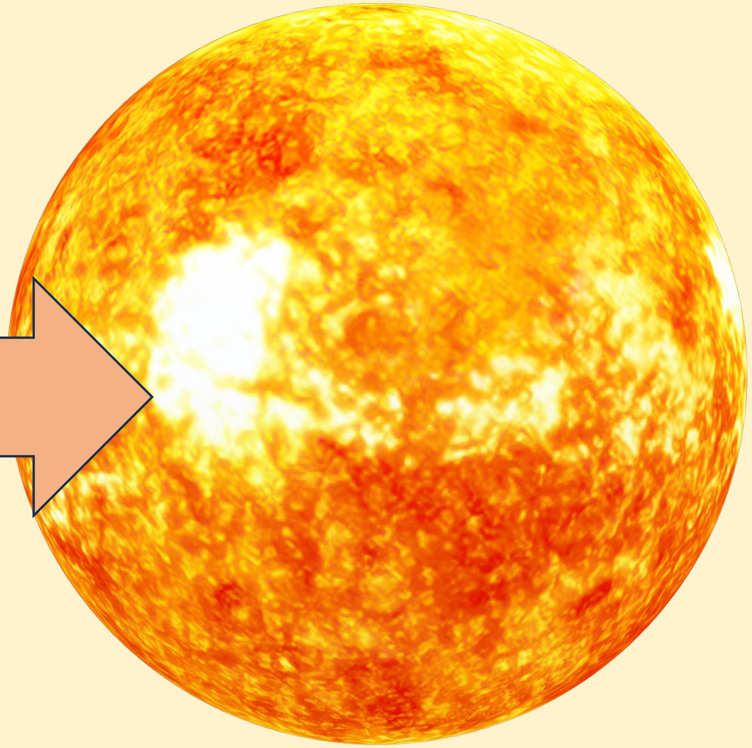


INTRODUCTION

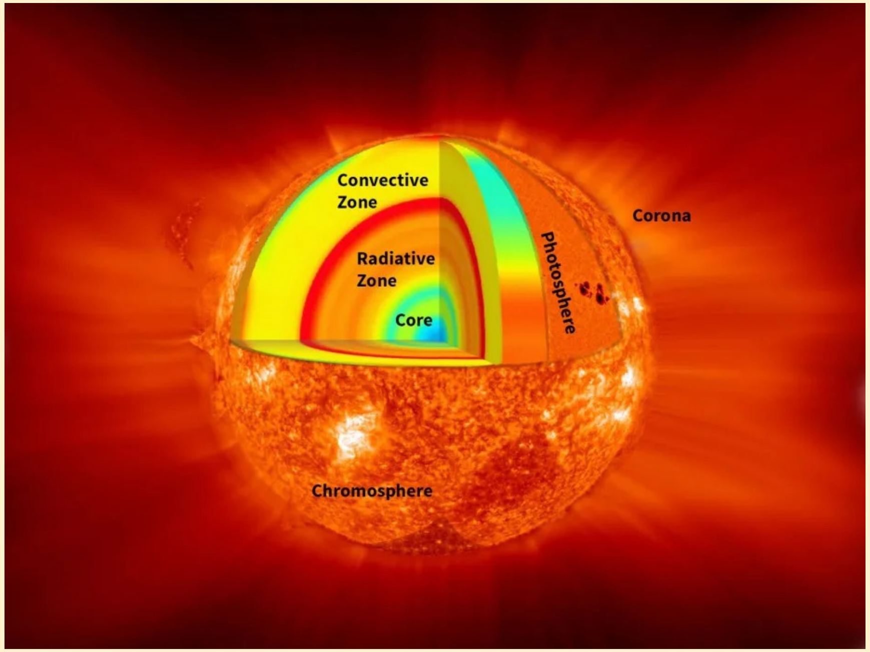


https://www.universetoday.com/156663/when-did-the-sun-blow-away-the-solar-nebula/

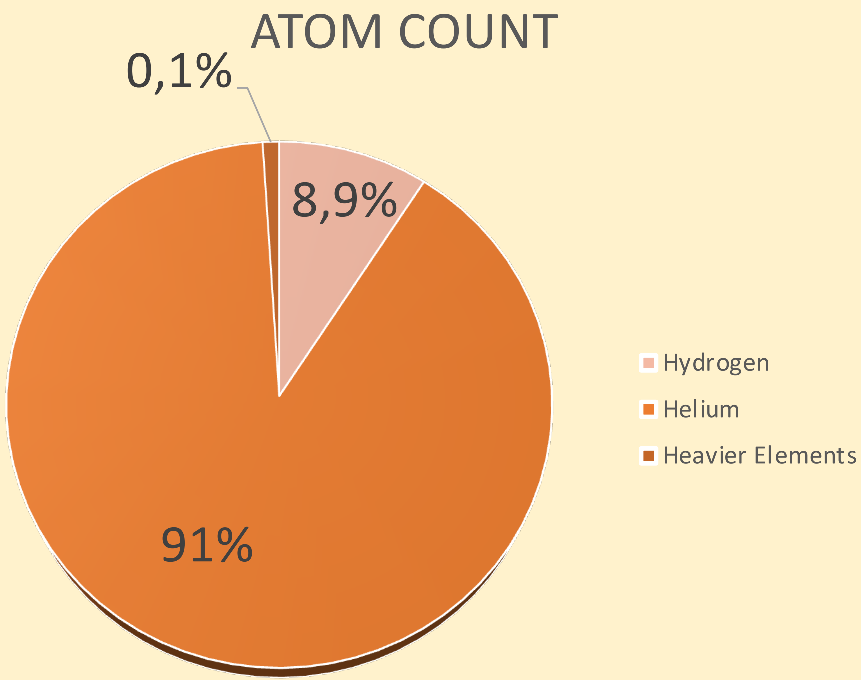
COLLAPSED



INTRODUCTION

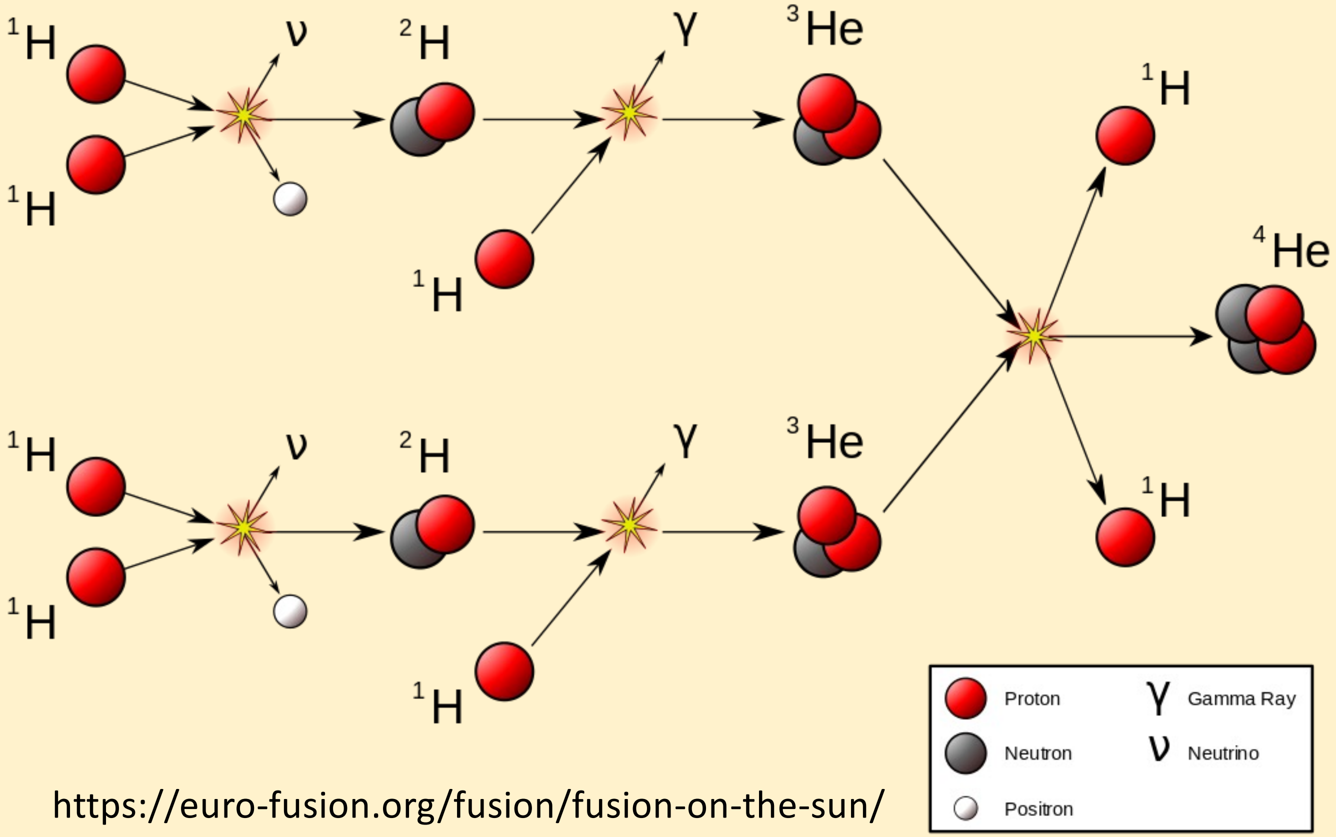


https://scied.ucar.edu/learning-zone/sun-space-weather/sun



Due to the sun's extreme temperatures these elements stay in a gas like phase called plasma

INTRODUCTION



https://euro-fusion.org/fusion/fusion-on-the-sun/

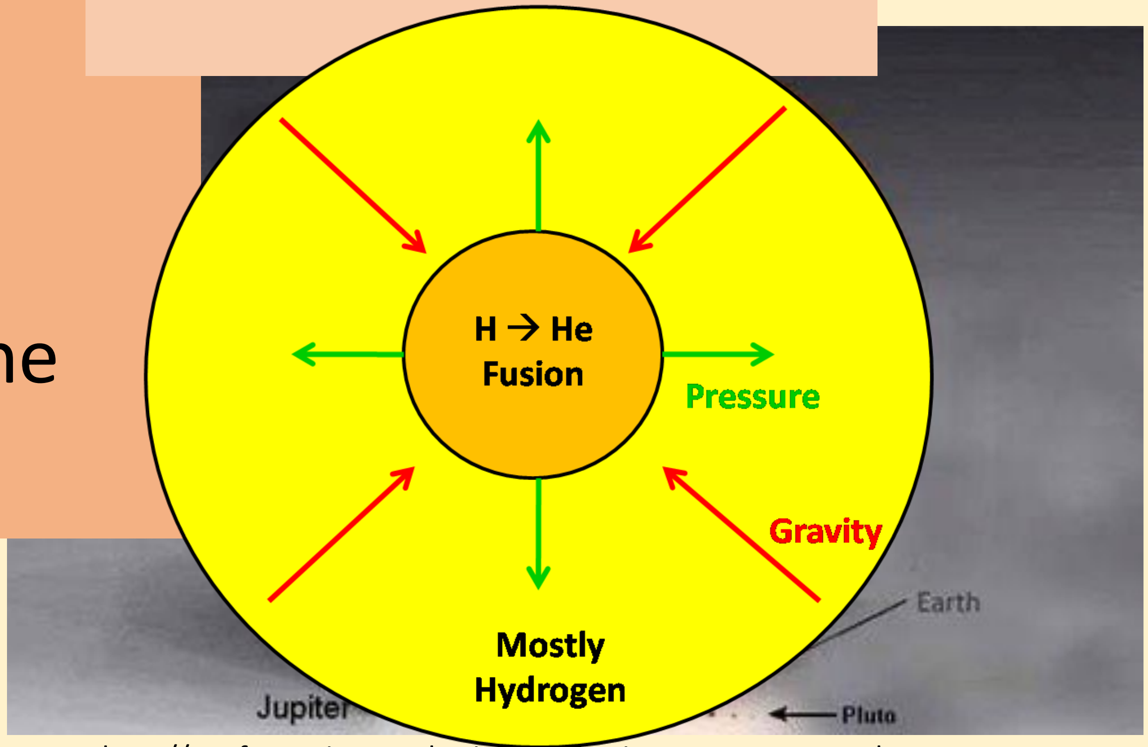
- Particles
  - Solar Wind
  - Electricity
- Waves
  - Light
  - Heat.

GRAVITY

- > 100 Earths wide
- $g = 274 m/s^2$
- 99.8% Mass of the Solar System

$$E = mc^2$$

↑ Energy
↑ Density



https://didyouknow.org/the-size-of-the-sun-in-comparison/
http://starformation.synthasite.com/main-sequence-stars.php

HYDROSTATIC EQUILIBRIUM

$$\frac{dP}{dr} = -\frac{G \ * m(r) * \rho}{r^2}$$

P: Pressure
r: Radius
G: Gravitational Constant
ρ: density

$$P = K * \rho^{\gamma}$$

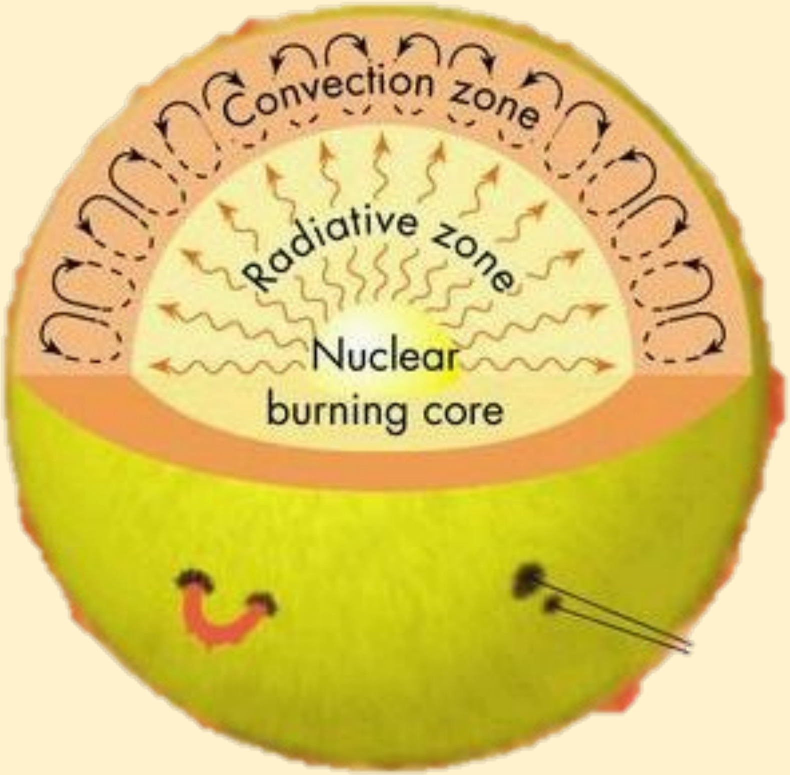
P: Pressure
ρ: Density
K and γ: Constant

Core overheats
↓
Increases the reaction rate
↓
Core expands
↓
Decreases the density
↓
Decreases the temperature due to expansion
↓
Reduces the reaction rate

Reaction Rate over attenuated
↓
Gravity becomes dominant
↓
Sun compresses and shrinks
↓
Increase the density
↓
Temperature increases
↓
Increases the reaction rate

Therefore, perturbations in either direction of the equilibrium will be neutralized by the Sun's auto-regulation mechanism.

SOLAR ENERGY BALANCE



https://people.astro.umass.edu/~myun/teaching/a100_old/longlecture10.html

RADIATIVE

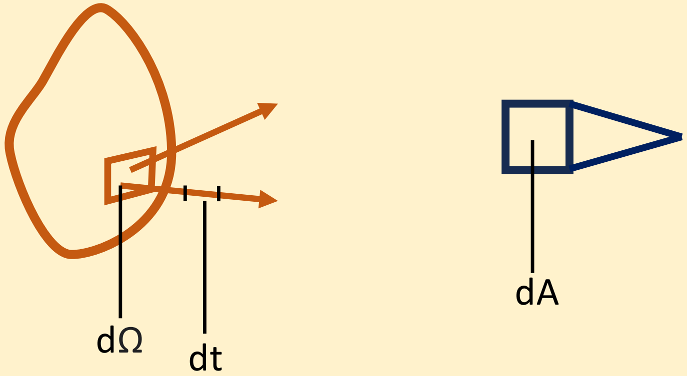
- Photons generated in the core carry energy outward
- Absorption and re-emission of photons as they navigate

CONVECTIVE

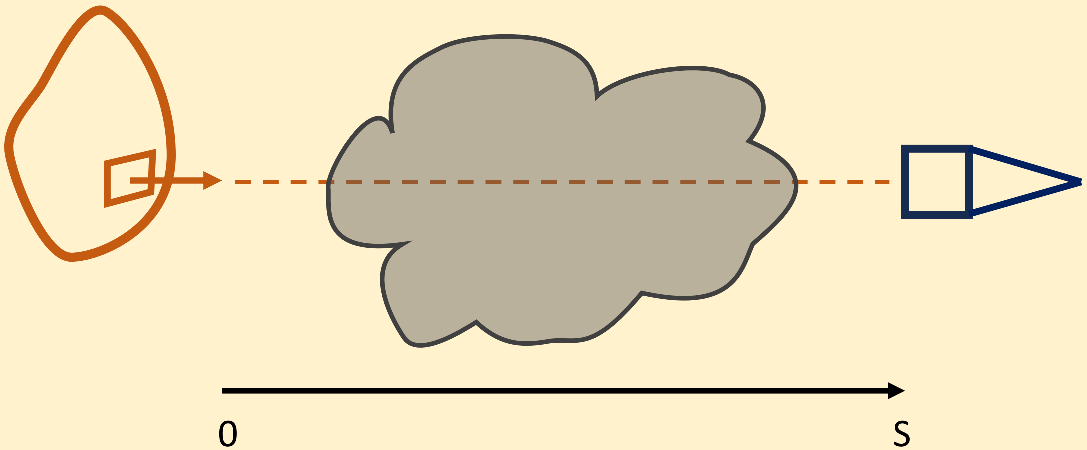
- Hot plasma rises to the surface
- Creating Granules

RADIATIVE TRANSPORT

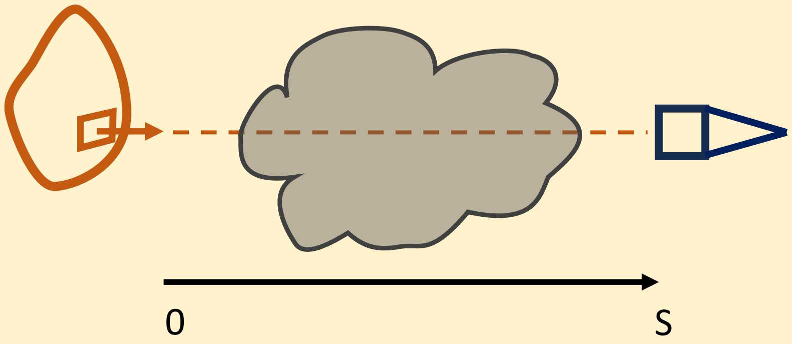
- Specific Radiation



$$I_n = \left[\frac{E}{t * f * A * \Omega}\right]$$



RADIATIVE TRANSPORT



$$\frac{dI_n}{dS} = j_n - k_n I_n$$

Emission (j_n) Scattering ($k_n I_n$)

K_n = Opacity

t_n = Optical depth

$$\frac{dI_n}{dS} = -k_n I_n \xrightarrow{K_n=\text{constant}} I_n(s) = I_{n0} * e^{-k_n S} \xrightarrow[K_n=\text{constant}]{dt_n = k_n * ds} I_n(s) = I_{n0} * e^{-t_n}$$

- $t_n = 1$ $\quad \frac{1}{e}$
- $t_n >> 1$ Optically thick
- $t_n << 1$ Optically thin

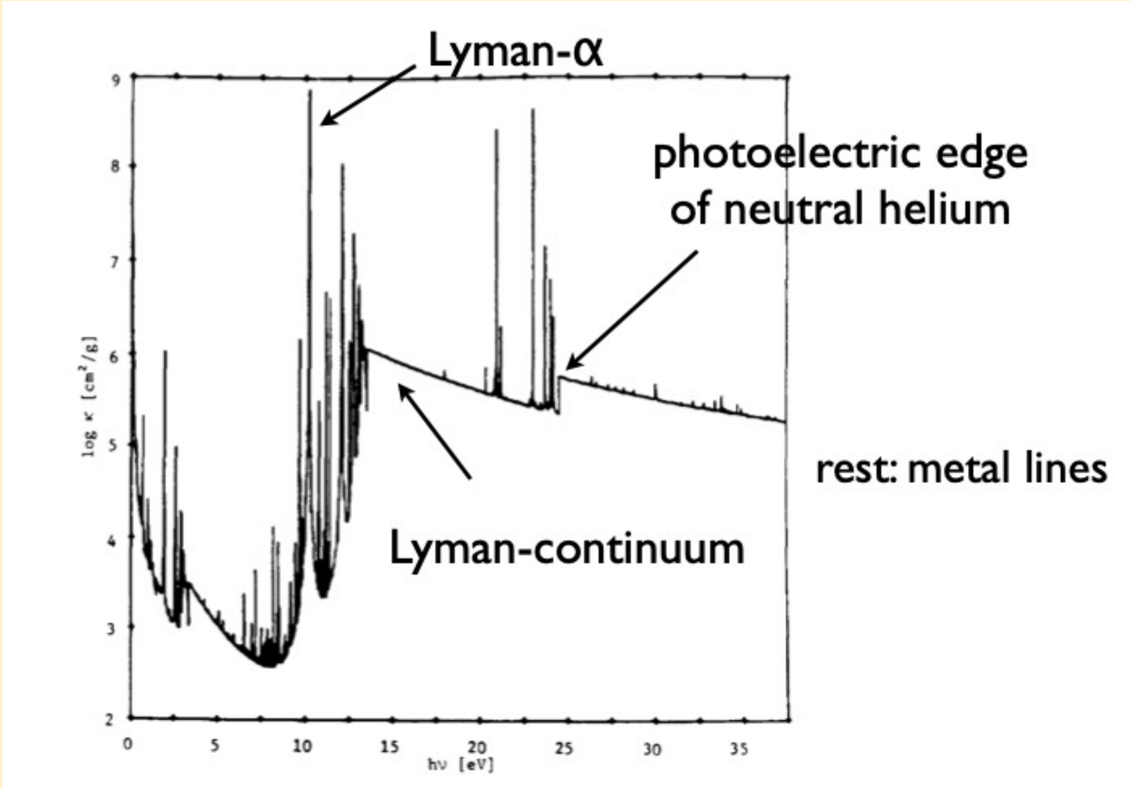
$$\frac{dI_n}{dS} * \frac{dS}{dt_n} = (j_n - k_n I_n)\frac{dS}{dt_n} \longrightarrow \frac{dI_n}{dt_n} = (\frac{j_n}{k_n} - I_n) \longrightarrow I_n(t_n) = I_{n0}e^{-t_n} + \frac{j_n}{k_n}(1 - e^{t_n})$$

Source function ($\frac{j_n}{k_n}$)

RADIATIVE TRANSPORT: OPACITY

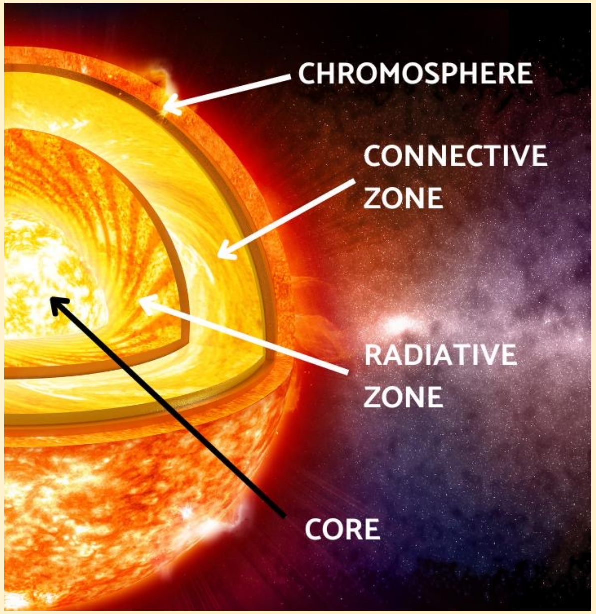
$$I_n(t_n) = I_{n0}e^{-t_n} + \frac{j_n}{k_n}(1 - e^{t_n})$$

$$t_n = f(k_n)$$
$$k_n = f(\nu)$$



Astrophysical concepts, M Harwit, Springer

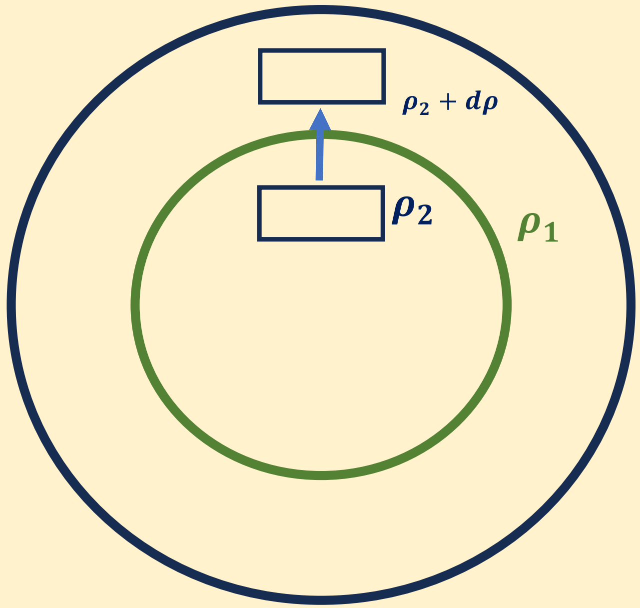
CONVECTIVE TRANSPORT

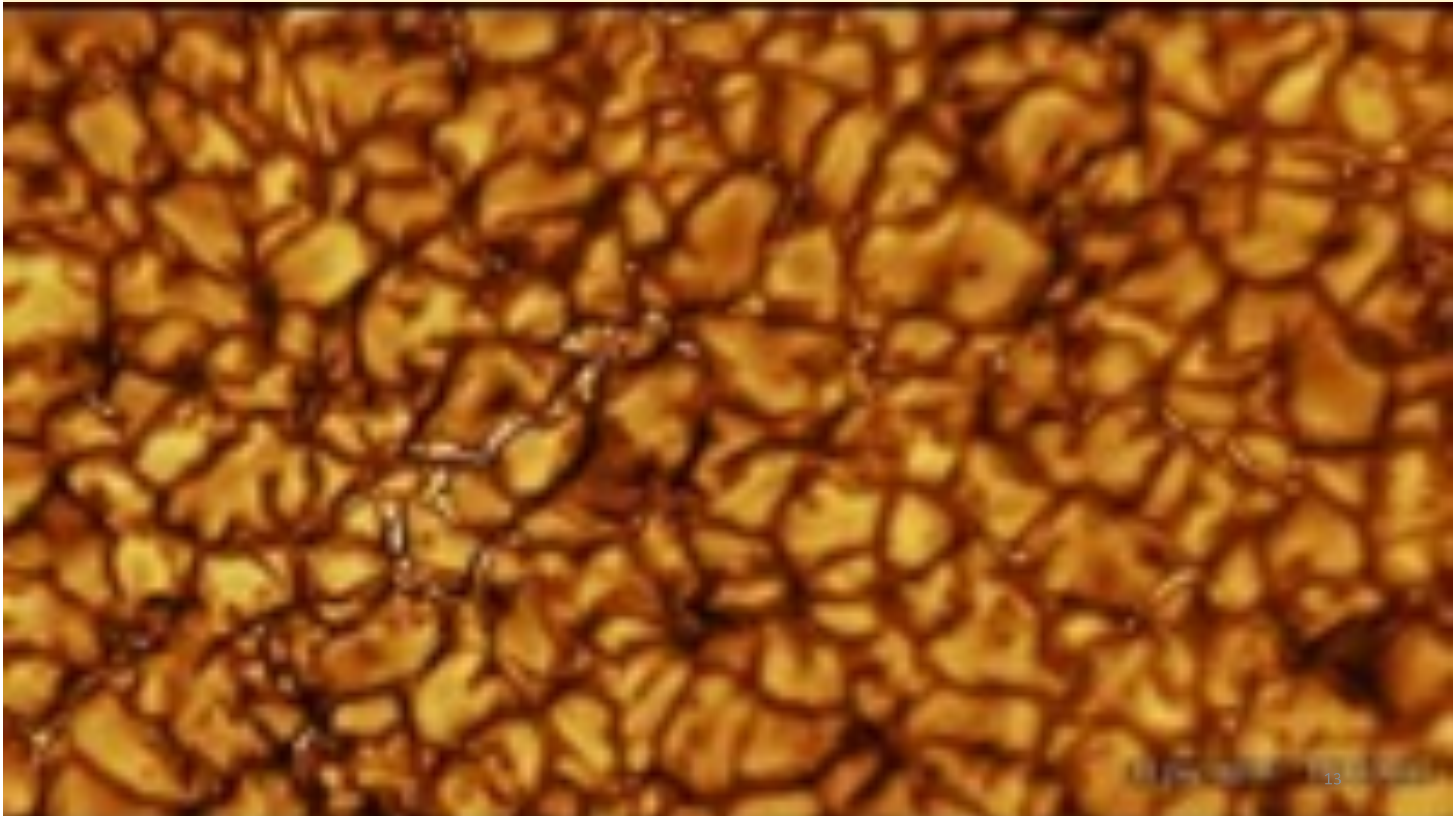


https://www.thedailyeco.com/what-are-the-layers-of-the-sun-381.html

- 30% Outsidest
- 2M ºC at the convective base
- The fluid starts to boil

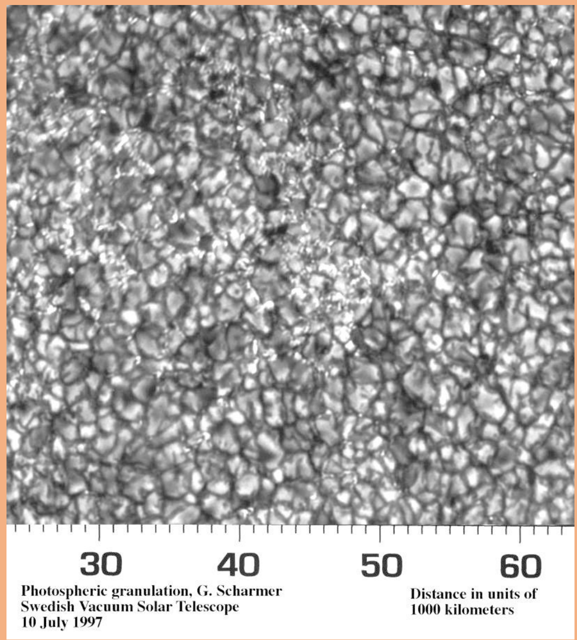
Temperature gradient of the sun > Adiabatic temperature gradient



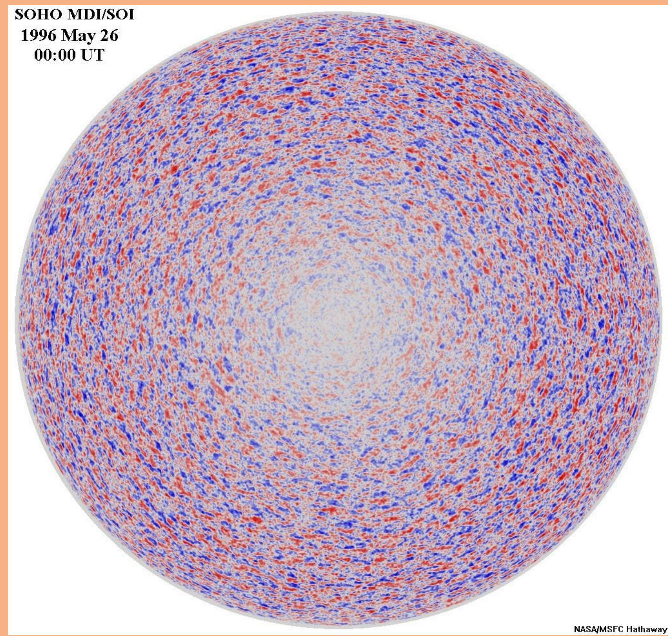


CONVECTIVE TRANSPORT

GRANULES



SUPERGRANULES

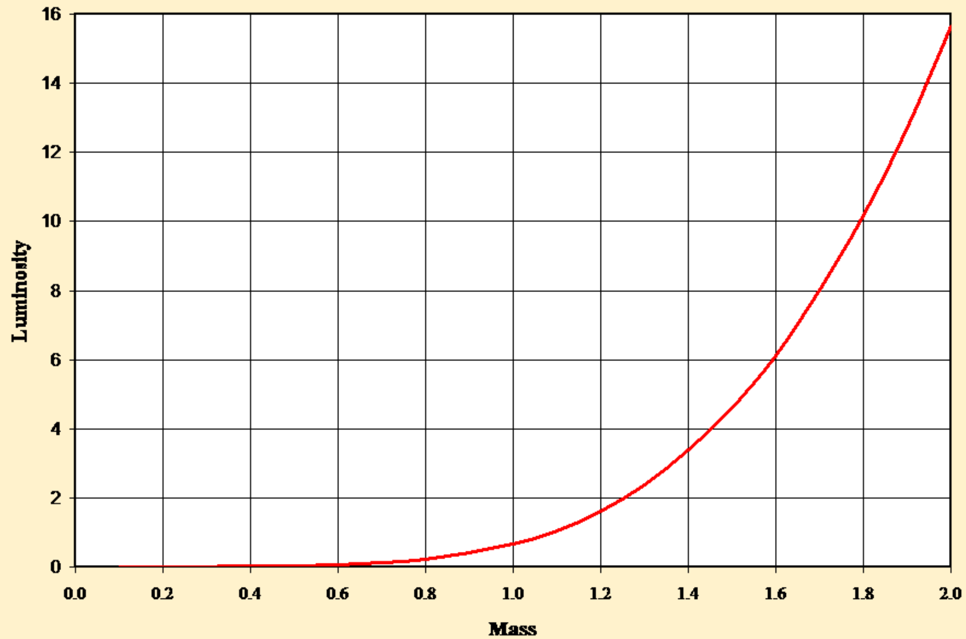


https://solarscience.msfc.nasa.gov/feature1.shtml#Granules

MASS – LUMINOSITY RELATION

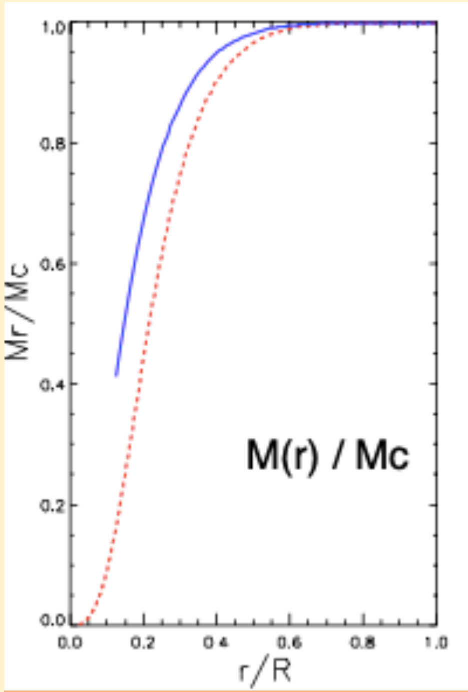
$$\frac{L}{L_S} = \left(\frac{M}{M_S}\right)^a \quad 1 < a < 6$$

- $a = 3.5$ only main sequence stars ($2M_s < M < 55M_S$)
- Red Giants and White Dwarfs do not apply

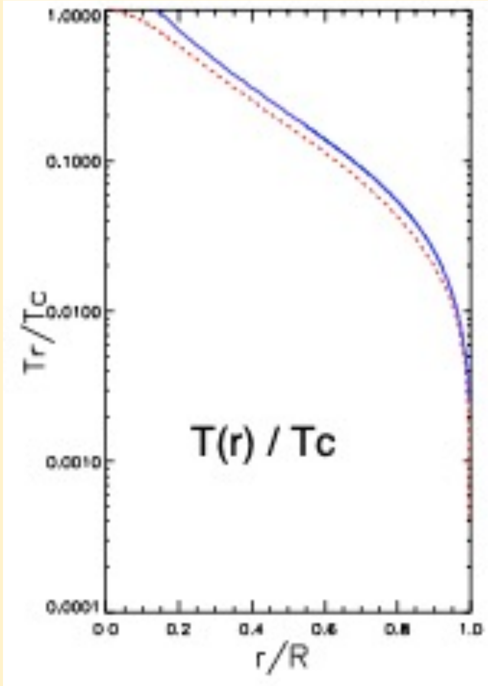


https://www.e-education.psu.edu/astro801/content/l7_p3.html

SOLUTIONS OF STELLAR EQUILIBRIUM

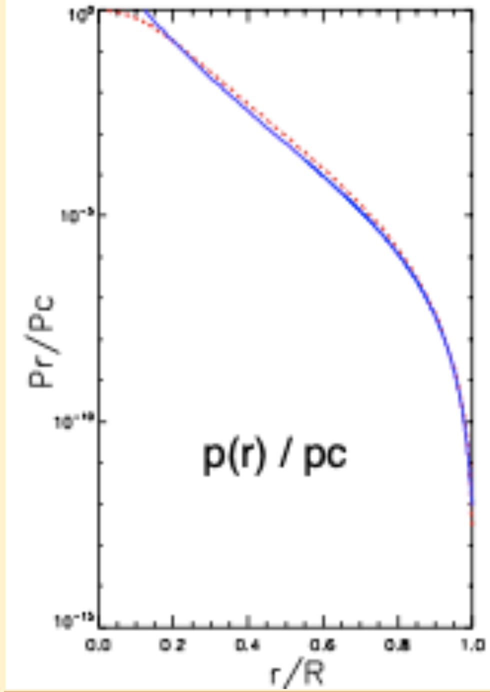


$$\frac{dM}{dr} = 4\pi r^2 \rho(r)$$



$$\frac{dT}{dr} = max[f(k_n), f(P)]$$

radiative convective



$$P(r) = \frac{\rho(r) k_B T(r)}{\mu(r) m_p}$$

All the graphs are taken from: Astrophysical concepts, M Harwit, Springer

ANY QUESTION?