

A ENERGIA DAS ESTRELAS: DA MATÉRIA À LUZ

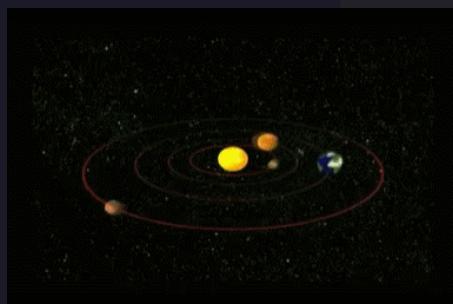
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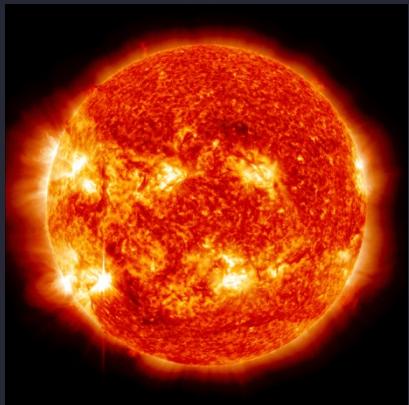
Mário João Monteiro

O que são as estrelas?

- "The nitrogen in our DNA, the calcium in our teeth, the iron in our blood, the carbon in our apple pies were made in the interiors of collapsing stars.

We are made of stardust."

Carl Sagan



A composição química

Hidrogénio



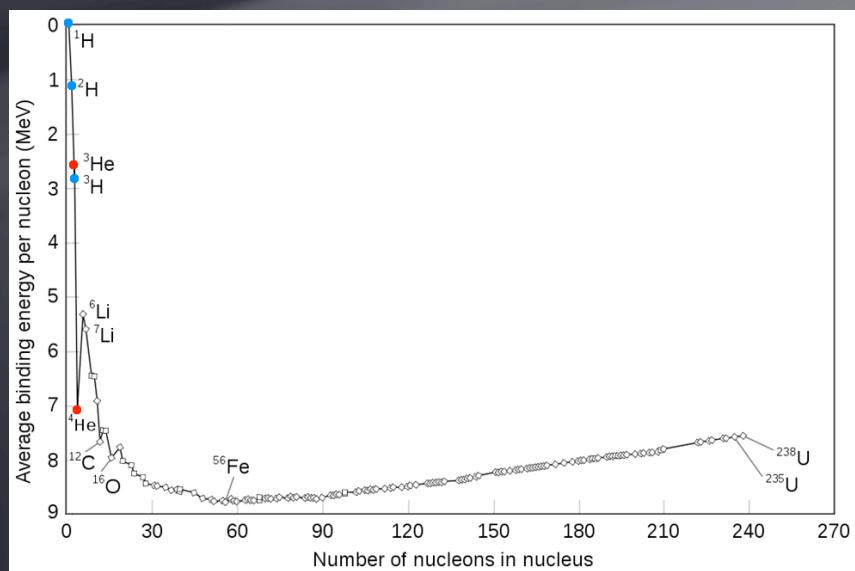
Hélio



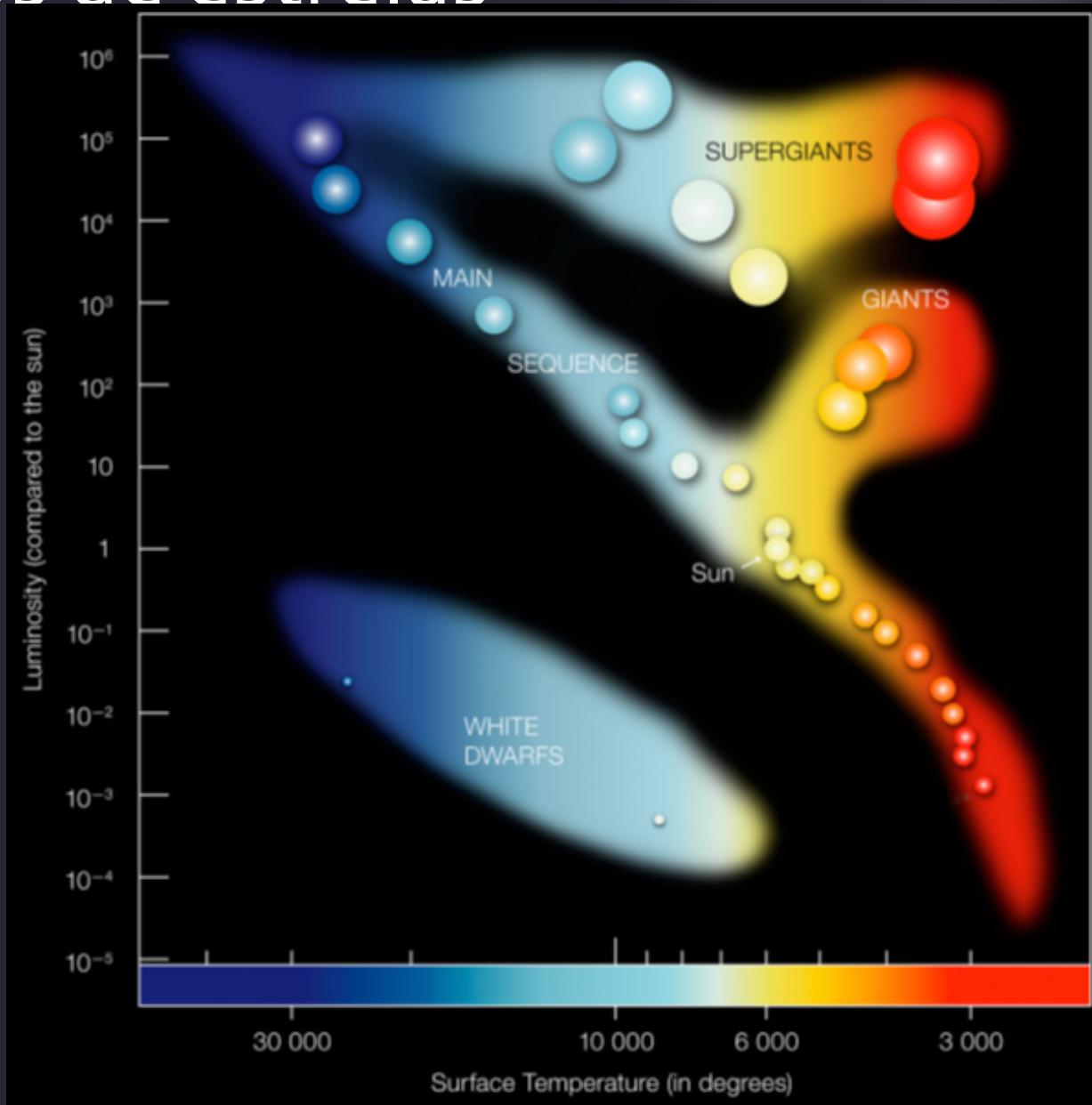
Carbono + Oxigénio

...

Até Ferro



Tipos de estrelas

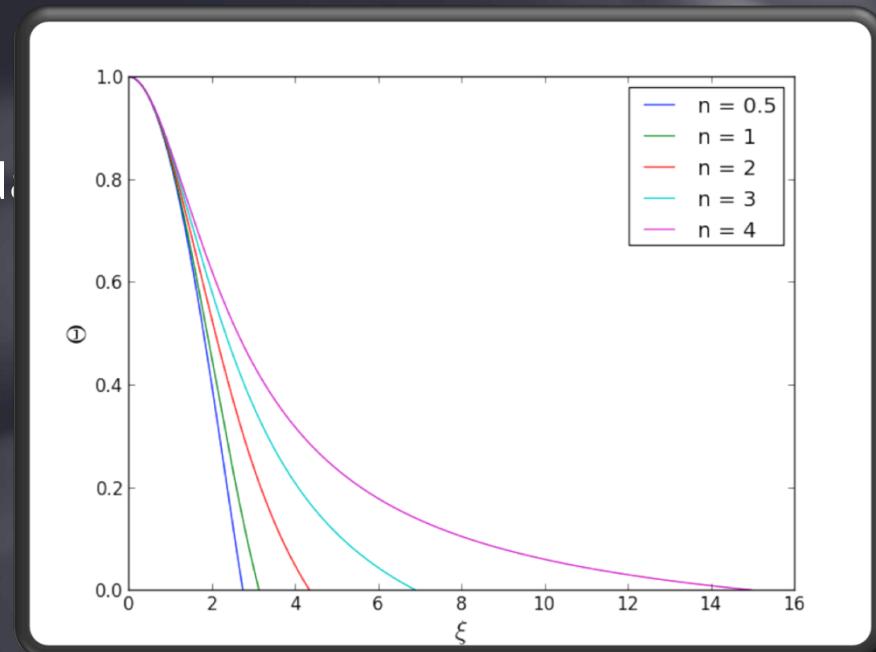


Física da estrutura

$dm/dr = 4 \pi r^2 \rho \rightarrow$ Conservação da massa

$dP/dr = -G m \rho / r^2 \rightarrow$ Equilíbrio das forças

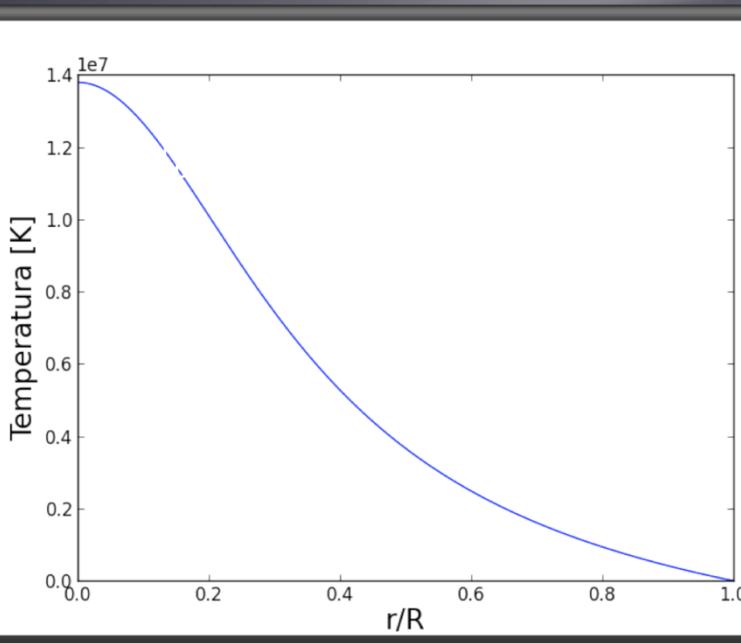
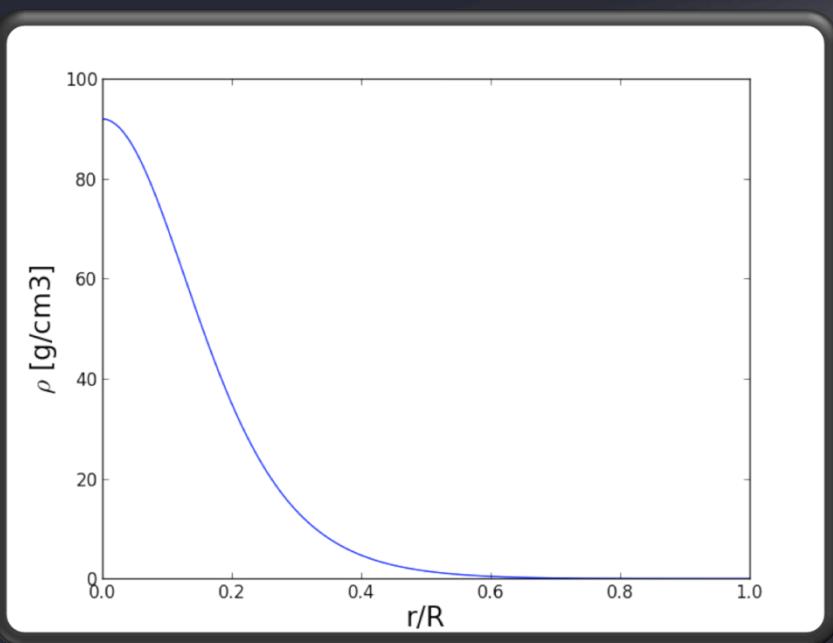
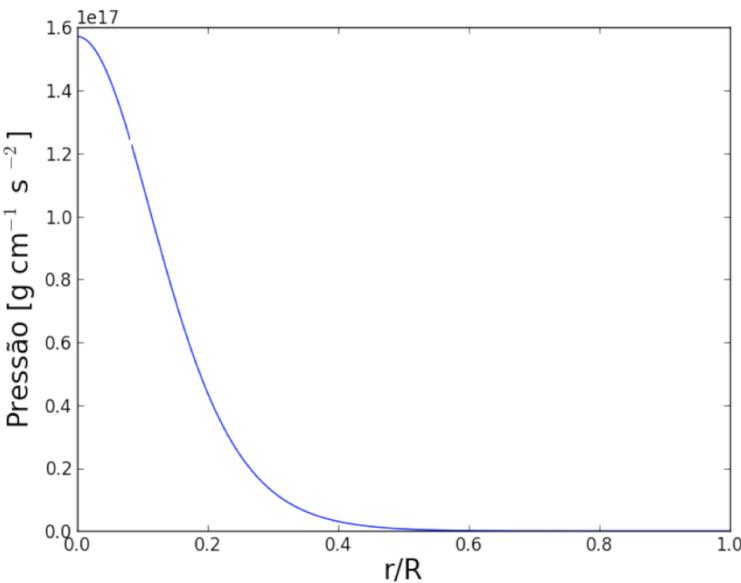
$P = k \rho^{1+1/n} \rightarrow$ Relação politrópica



Sol

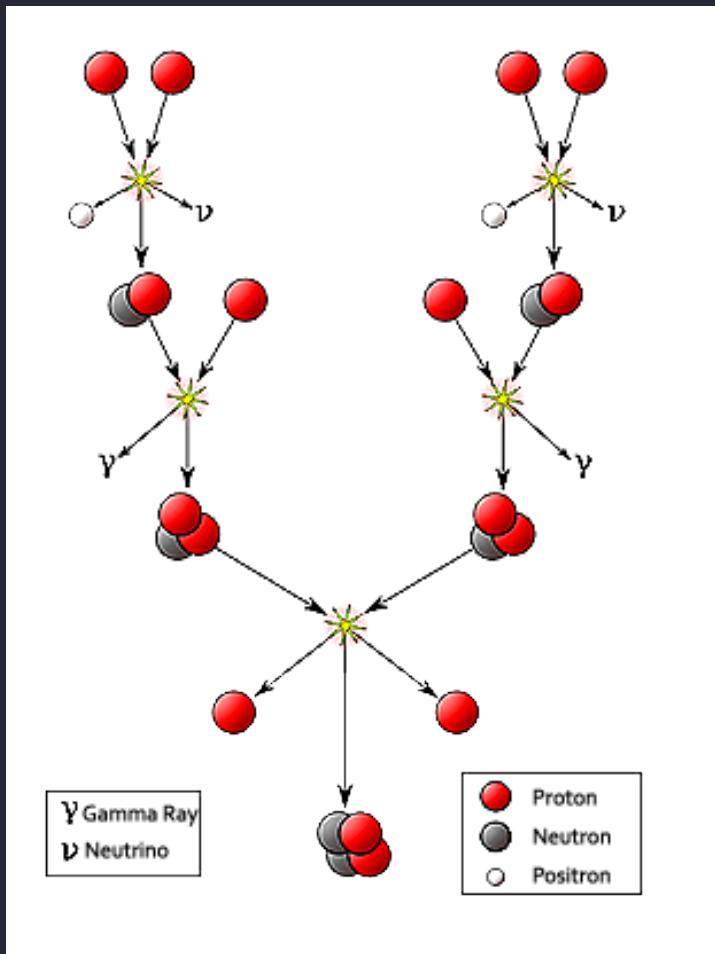
Parâmetros

- Massa = 1.9891×10^{133} g
- Raio = 6.9634×10^{10} cm
- $n = 3.1$



Fusão de Hidrogénio

Reação



Energia aproveitada

$$4 \times M_{\text{Protão}} - M_{\text{Hélio}} = m$$

$$E = m c^2 = 3.9614395 \times 10^{-5} \text{ erg}$$

Taxa de Produção de Energia

$$\varepsilon(\rho, T) = \varepsilon_0 X^2 \rho T^4 \text{ [erg/g/s]}$$

A reação ocorre para $T \gtrsim 10^{17} \text{ K}$

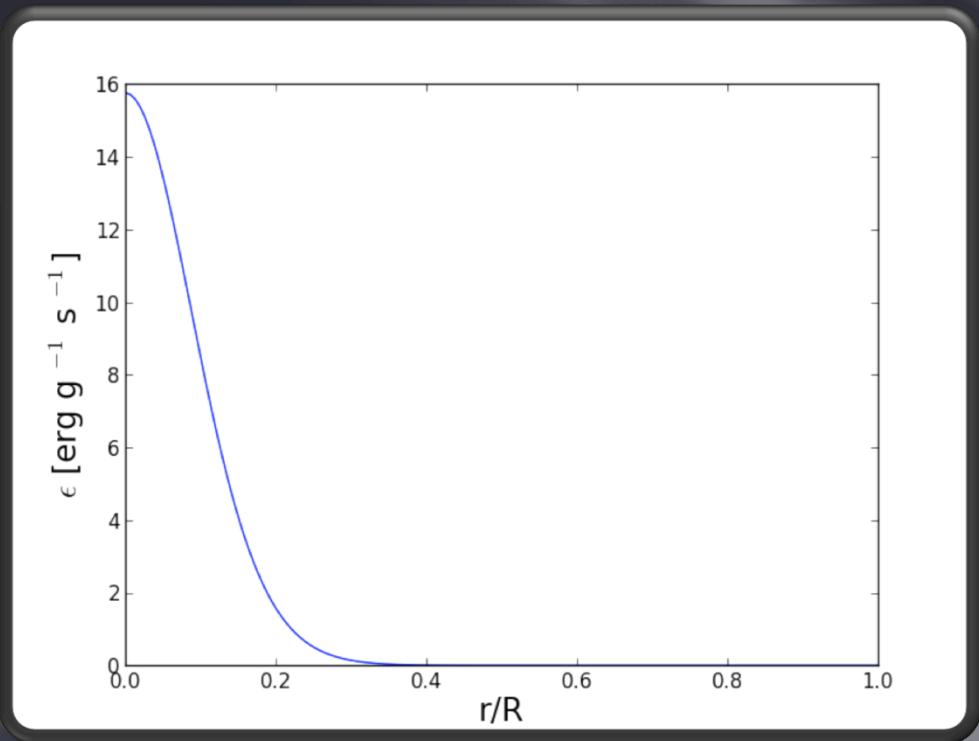
Luminosidade

Luminosidade é a energia total perdida pela estrela por unidade de tempo.

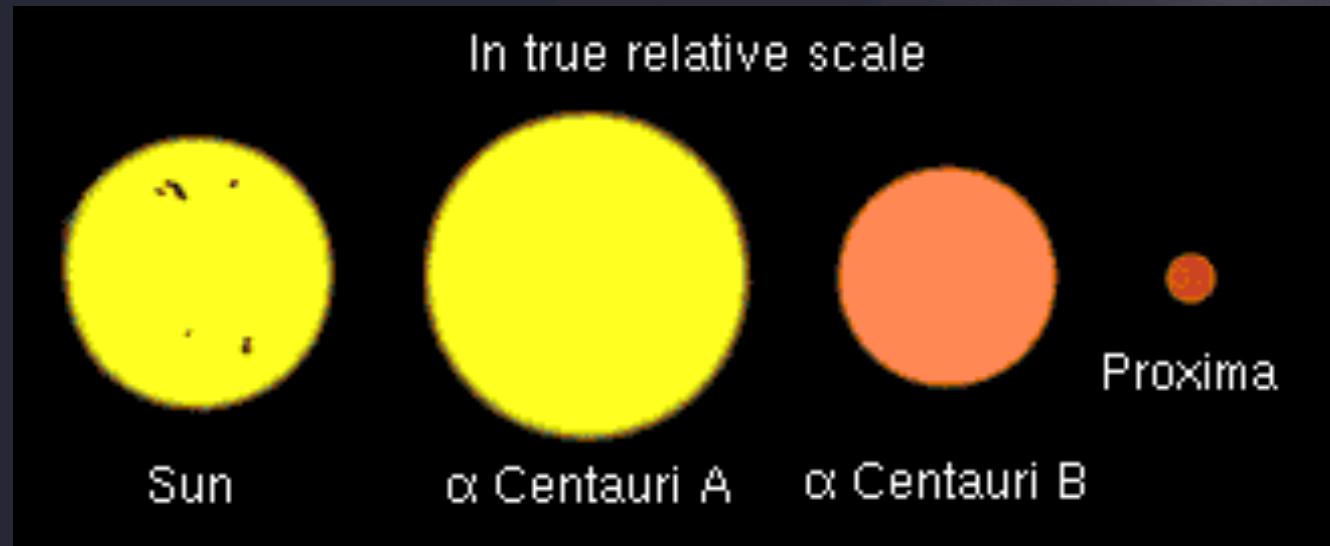
Para o sol

$$L_{\text{sol}} = 3.846 \times 10^{33} \text{ erg/s}$$

$$dL/dr = 4 \pi r^2 \rho \epsilon$$

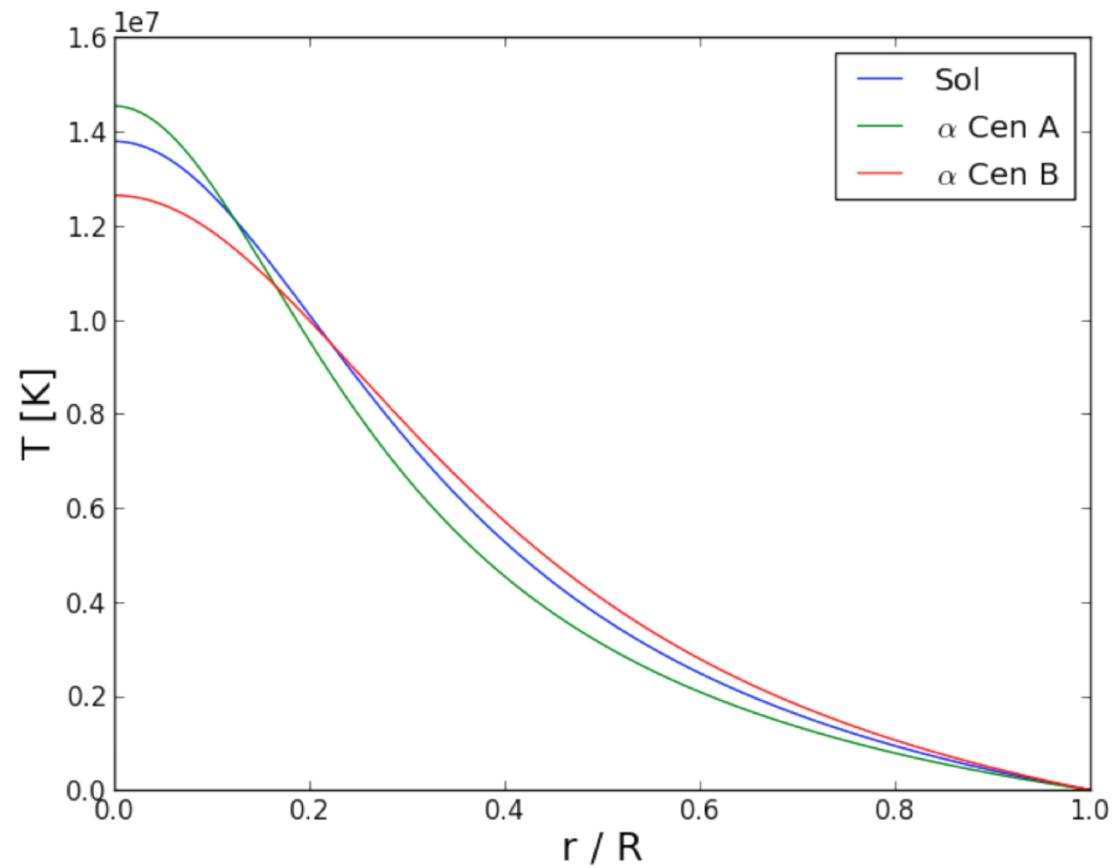


Outras estrelas



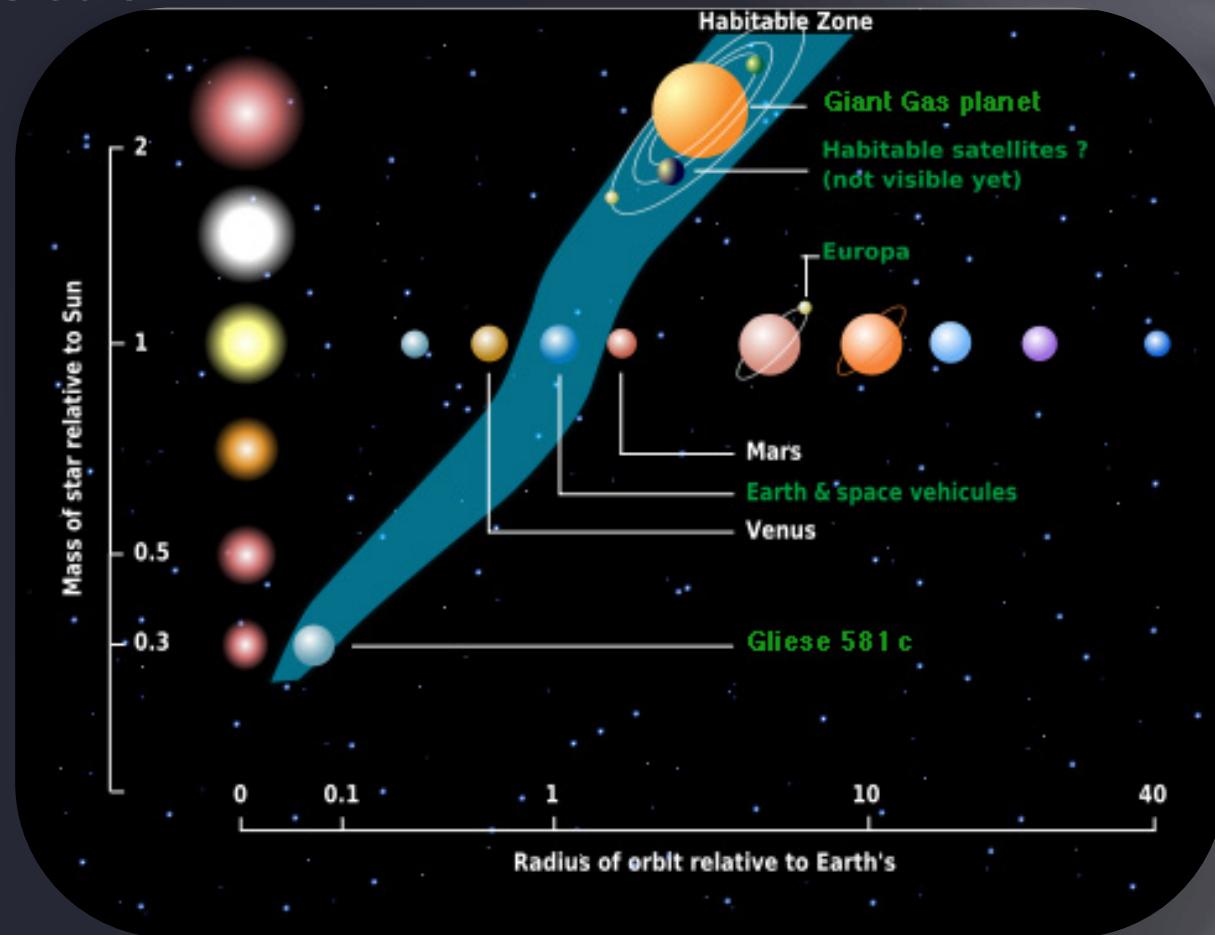
$M=1.100$	$M=0.907$
$M \downarrow sol$	$M \downarrow sol$
$R=1.227$	$R=0.865$
$R \downarrow sol$	$R \downarrow sol$
$L=1.519$	$L=0.500$
$L \downarrow sol$	$L \downarrow sol$

Outras estrelas



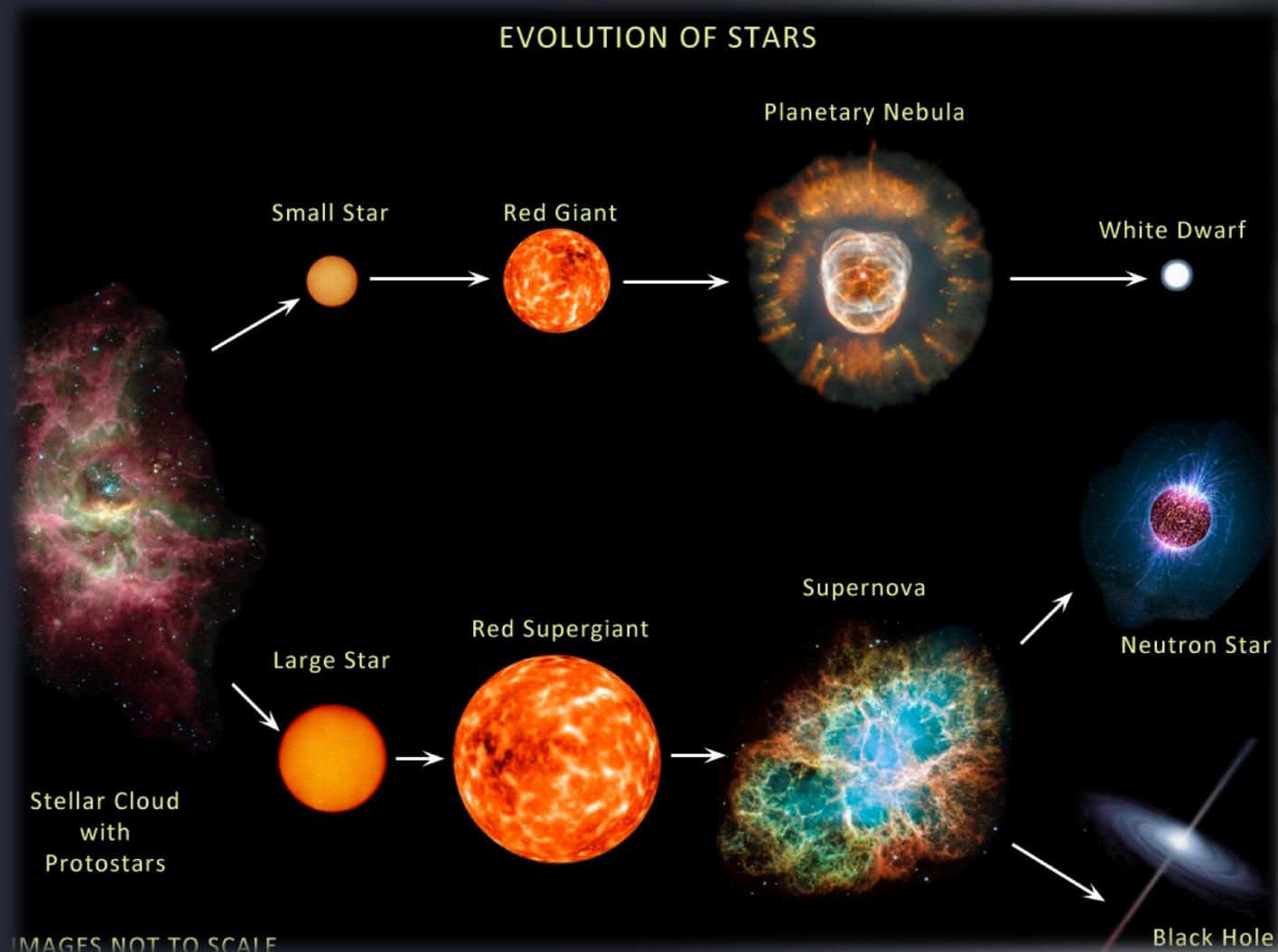
Sol: $n=3.1$
 α Centauri A: $n=3.4$
 α Centauri B: $n=2.8$

Importância da luminosidade para os planetas



$$E_{\oplus} = \frac{\pi R_{\oplus}^2}{4\pi a^2} \cdot L_{\odot} \simeq 4.6 \times 10^{-10} L_{\odot}$$

Evolução das estrelas



Idade do sol = 4.6×10^{19} anos



Obrigado pela “atenção”!