Friday, March 21, 2025

Luminosity of a White Dwarf (just born)

$T = 200{,}000\ K = 2 \times 10^5\ K$ [in the Butterfly Nebula NGC 6302]

$M = 0.64\ M_{sun}$

↳ According to white Dwarf radius vs mass plot

$M = 0.64\ M_{sun}$ corresponds to $R = 0.012\ R_{sun}$

$R(0.64) = 0.012$

Wien's Law: peak wavelength: $\lambda_{max}^{nm} = \frac{2.9 \times 10^6}{200{,}000} = 14.5\ nm$

$\Rightarrow \boxed{\lambda_{max}^{nm} = 14.5\ nm}$ This wavelength is in the extreme ultraviolet (EUV)

this light will ionize any atom or molecule

Stefan-Boltzmann Law

Surface intensity $= \sigma T^4$

$= \left(5.67 \times 10^{-8} \frac{W}{m^2 \cdot K^4}\right)\left(2 \times 10^5\ K\right)^4$

$= 9.07 \times 10^{13} \simeq 9 \times 10^{13}\ W/m^2$

Surface intensity $= 9 \times 10^{13}\ W/m^2$

note: for our sun, the surface intensity is $6.4 \times 10^7\ W/m^2$

↑

~ million times more intense than the surface of our sun.

Surface area of white Dwarf

Surface area $= 4\pi R^2 = 4(3.1415926)(8.35 \times 10^6)^2$

$= 8.77 \times 10^{14}\ m^2$

$R = 0.012\ R_{sun}$

$= (0.012)(6.96 \times 10^5\ km)$

$6.96 \times 10^8\ m$

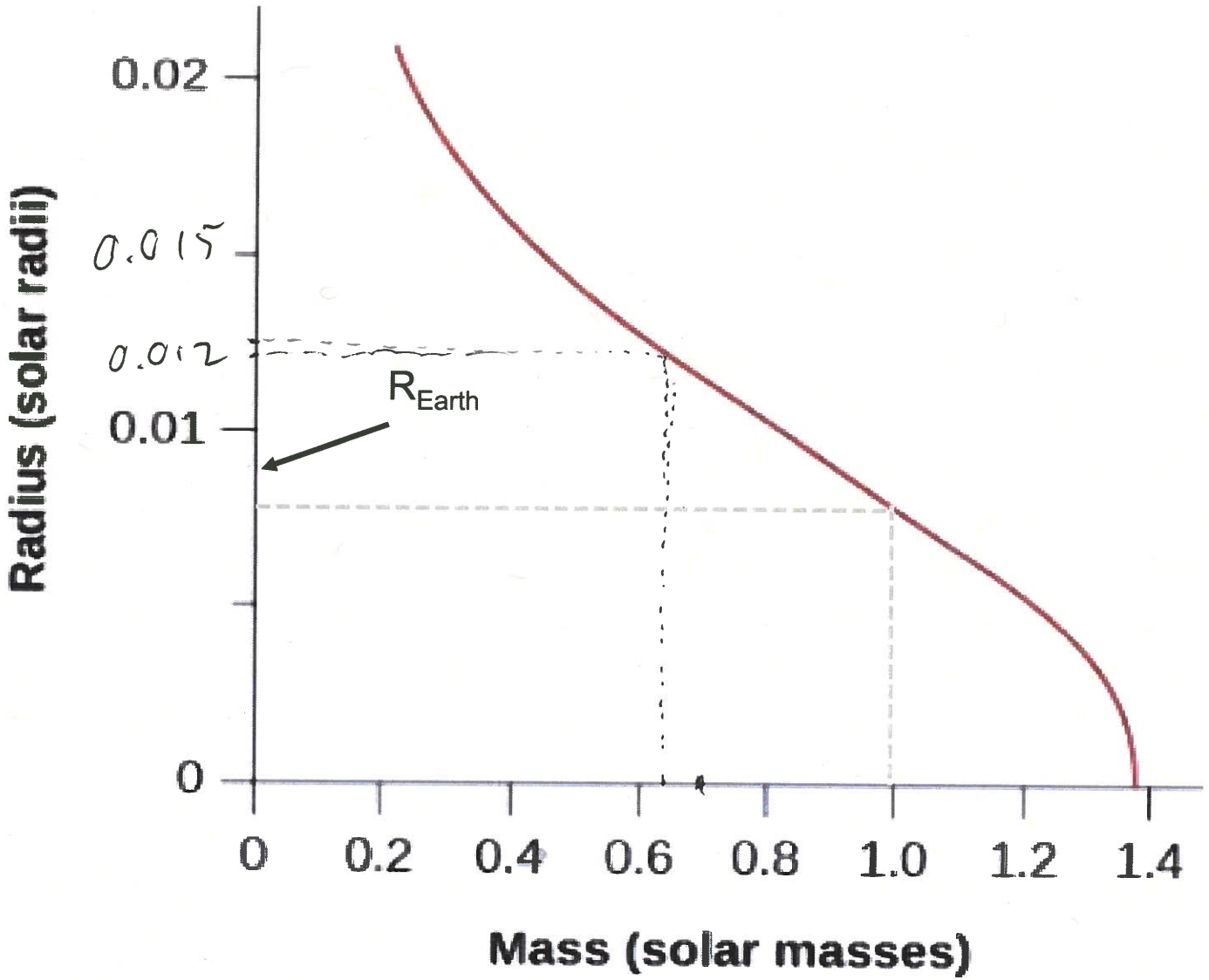
$= 8.35 \times 10^6\ m$

Luminosity = total output power = Surface intensity (W/m^2) × surface area (m^2)

$= (9 \times 10^{13}\ W/m^2)(8.77 \times 10^{14}\ m^2)$

$= 7.95 \times 10^{28}\ W \simeq 8 \times 10^{28}\ W$

Luminosity of white Dwarf (just born) $= 8 \times 10^{28}\ W$ $\simeq 200\ L_{sun}$


0.02
0.015
0.012
0.01
0
Radius (solar radii)
R_{Earth}
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Mass (solar masses)