Friday, March 20, 2026

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 the White Dwarf radius vrs. 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 = 9×10^{13} W/m^2

Note: For our Sun, the surface intensity is 6.4×10^7 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

$R = 0.012\ R_{sun}$

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

6.96×10^8 m

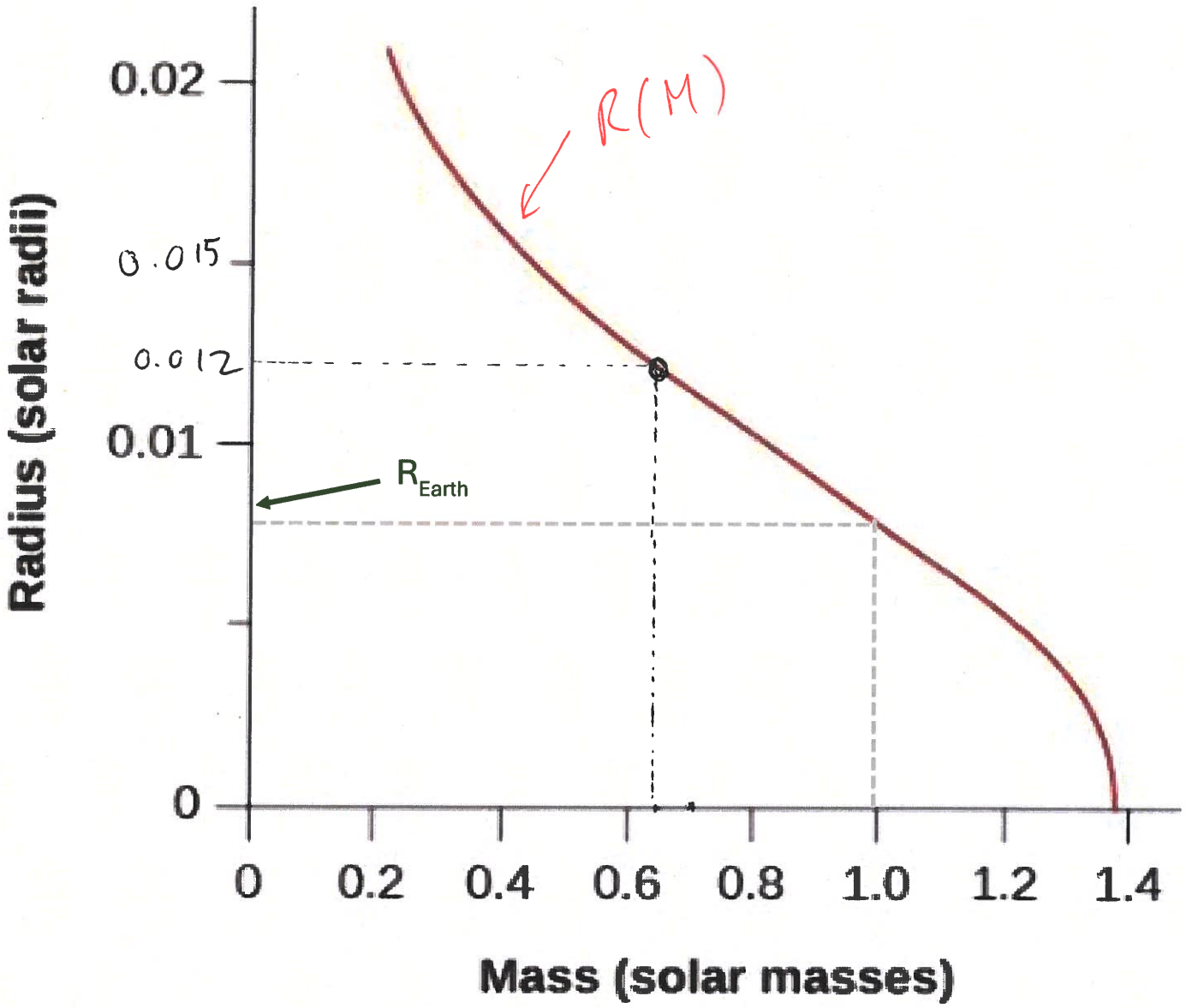
$= 8.35 \times 10^6$ m

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) = 8×10^{28} W $\simeq 200\ L_{sun}$


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