

## Astronomy (PY 101)

NAME \_\_\_\_\_

### Project V: Main-Sequence Lifetime versus Mass

The luminosity  $L$  of a star was shown in Project III to be a strong function of its mass  $\mathcal{M}$ . The data showed that

$$\frac{L}{L_{\odot}} = \left( \frac{\mathcal{M}}{\mathcal{M}_{\odot}} \right)^{3.5}$$

Since the luminosity of a Main Sequence (MS) star is fairly constant throughout its stay in the MS phase, the MS lifetime  $\tau$  is defined as the ratio of the total energy  $\mathcal{E}$  produced by the MS star to the MS luminosity  $L$ . Since the total energy  $\mathcal{E}$  is proportional to the star's mass  $\mathcal{M}$ , we find that the MS lifetime  $\tau(10^9 \text{ y})$ , evaluated in billions of years, is expressed as

$$\tau(10^9 \text{ y}) = 12 \times \frac{(\mathcal{M}/\mathcal{M}_{\odot})}{(L/L_{\odot})}.$$

Hence, the MS lifetime of the Sun is expected to be  $\tau_{\odot} = 12$  billion years. The logarithm of the MS lifetime is therefore calculated as

$$\log(\tau_{by}) = \log(12) + \log(\mathcal{M}/\mathcal{M}_{\odot}) - \log(L/L_{\odot})$$

where  $\tau_{by} = \tau(10^9 \text{ y})$  denotes the MS lifetime in billions of years.

$\log(\mathcal{M}/\mathcal{M}_{\odot})$	$\log(L/L_{\odot})$	$\log(\tau_{by})$
-1.0	-2.9	
-0.8	-2.5	
-0.6	-2.0	
-0.4	-1.5	
-0.2	-0.8	
0.0	0.0	
0.2	0.8	
0.4	1.6	
0.6	2.3	
0.8	3.0	
1.0	3.7	
1.2	4.4	
1.4	4.9	
1.6	5.4	
1.8	6.0	

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**Part 1:** Complete the data table above by computing the logarithms of MS lifetime  $\tau_{by}$ .

**Part 2:** Plot  $\log(\tau_{by})$  versus  $\log(\mathcal{M}/\mathcal{M}_{\odot})$  on a graph and **connect the dots to the best of your ability**.

**Part 3:** Using your graph, calculate the MS lifetimes of MS stars of masses  $0.5 \mathcal{M}_{\odot}$ ,  $2 \mathcal{M}_{\odot}$ , and  $10 \mathcal{M}_{\odot}$ :

$$\tau_{by}(\mathcal{M}/\mathcal{M}_{\odot} = 0.5) = \underline{\hspace{2cm}}$$

$$\tau_{by}(\mathcal{M}/\mathcal{M}_{\odot} = 2.0) = \underline{\hspace{2cm}}$$

$$\tau_{by}(\mathcal{M}/\mathcal{M}_{\odot} = 10.0) = \underline{\hspace{2cm}}$$

