

Climate Change workshop #4

**Estimate the Sun's main-sequence age**

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The Sun started out as mostly Hydrogen (H) with a little Helium (He).

The primordial ratio of H/He = 9/1.

The Sun fuses 4 H to 1 He and emits energy due to the mass difference:

$E = \Delta M c^2$  where  $\Delta m = 0.7\%$  of the H mass fused, and  $c = 3 \times 10^8$  m/s = speed of light.

$$c^2 = (3 \times 10^{10} \text{ cm/s})^2 = 9 \times 10^{20} \text{ cm}^2/\text{s}^2 \sim 10^{21} \text{ cm}^2/\text{s}^2$$

10% of the H mass is converted to He

The Sun's total mass  $M = 2 \times 10^{30}$  kg hardly changes

$M_H / M = 70\%$  and  $M_{He} / M = 30\%$

The Sun emits energy at a somewhat constant rate of  $L = 4 \times 10^{33}$  ergs / sec

Units:	acceleration	force	energy
cgs	cm/s <sup>2</sup>	g.cm/s <sup>2</sup>	erg = g.cm <sup>2</sup> /s <sup>2</sup>
MKS	m/s <sup>2</sup>	kg.m/s <sup>2</sup>	joule = kg.m <sup>2</sup> /s <sup>2</sup>

The luminosity of the Sun:  $L = \text{power} = \text{energy} / \text{time} = E_{\text{burned}} / T$

Therefore the lifetime of the Sun is  $T = E_{\text{burned}} / L$  where

$$E_{\text{burned}} = 10\% * 0.7\% * 0.70 * M c^2 = 10^{-1} * 7 \times 10^{-3} * 7 \times 10^{-1} * 2 \times 10^{33} \text{ g} * 10^{21} \text{ cm}^2/\text{s}^2$$
$$E_{\text{burned}} \sim 10^{51} \text{ g cm}^2/\text{s}^2$$

$$T = E_{\text{burned}} / L = (10^{51} \text{ g cm}^2/\text{s}^2) / (4 \times 10^{33} \text{ ergs} / \text{sec})$$

$$T \sim \frac{1}{4} \times 10^{18} \text{ s} \mid \text{yr} / 3 \times 10^7 \text{ s} \mid \sim 1/12 \times 10^{11} \text{ yr} \sim 10^{10} \text{ yr}$$

$T \sim 10$  billion years – right.