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 Dm = 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^2	$g.cm/s^2$	erg = $g.cm^2/s^2$
MKS	m/s^2	$kg.m/s^2$	joule = $kg.m^2/s^2$

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

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

$E_{burned} = 10\% * 0.7\% * 0.70 * M\, c^2 = 10^{-1} * 7x10^{-3} * 7x10^{-1} * 2x10^{33}$ g $* 10^{21}$ cm^2/s^2
$E_{burned} \sim 10^{51}$ g cm^2/s^2

$T = E_{burned} / L = (10^{51}$ g $cm^2/s^2) / (4 \times 10^{33}$ ergs / sec)
$T \sim ¼ \times 10^{18}$s | yr / $3x10^7$s| ~ 1/12 x 10^{11} yr ~ 10^{10} yr
T ~ 10 billion years – right.