Estimating the Main Sequence life span of the Sun

- Don’t worry – you don’t need to understand these things to this level of detail.
- But someone in class asked, so I thought it worth showing how it’s done.
- What you will see is just an estimate.
- Computer models predict the time evolution of our Sun (and other stars) in great detail – and with a ***whole lot more physics*** thrown in...

Estimating MS life span of our Sun

- Sun converts 4.3×10^9 kg into energy every second:

  $$4.3 \times 10^9 \text{ kg/s} \times c^2 = 3.8 \times 10^{26} \text{ W} = L_{Sun}$$

- 614×10^9 kg of H is converted into 610×10^9 kg of He each second; difference in mass is that converted to energy (see first bullet)
- 70% of Sun's total mass is H, but only about 10% is available for fusion within core: $0.1M_{sun} = 2 \times 10^{29}$ kg
- $t_{MS} \approx$ available H mass / H consumption rate = $(2 \times 10^{29} \text{ kg} / 614 \times 10^9 \text{ kg/s}) / (3.156\times10^7 \text{ s/yr}) \approx$ **10^{10} years**
- best computer models predict **10.0 billion year** MS life span for star of Sun's mass and composition.

Another way of looking at it…

- Sun converts 4.3×10^9 kg into energy every second: 4.3×10^9 kg/s $\times c^2 = 3.8 \times 10^{26}$ W $= L_{Sun}$
- $t_{MS} \approx \eta \times (f \times \mathbf{M_{Sun}}) \times c^2 / \mathbf{L_{Sun}} \propto \mathbf{M / L}$ (as we said in class)
  - $f \times M_{Sun}$ = fraction of Sun's mass that undergoes H fusion (about 10%) = 2×10^{29} kg
  - η = relative mass difference : $(4\,^1H - {}^4He) / 4\,^1H$ = 0.007, i.e., 0.7% mass involved per reaction is turned into energy
  - note that 0.007 = (4.3×10^9 kg/s) / (**614×10^9 kg/s**)

$t_{MS} \approx (0.007 \times 2 \times 10^{29}$ kg $\times c^2 / 3.8 \times 10^{26}$ W) / (3.156×10^7 s/yr) $\approx$ **10^{10} years**