Einstein postulated (1905):

- The Principal of Relativity. The laws of physics are the same in all inertial reference frames.
- The constancy of the speed of light. Light travels through a vacuum at a speed \( c \) which every observer measures to be the same.

\[ v' = (v-u) \]

\[ v' = \frac{v-u}{\sqrt{1-\frac{uv}{c^2}}} \]

\[ \text{Distance, time, velocity add up in funny ways} \]

\[ \text{Total energy of a particle moving at constant velocity } v: \]

Classical: \[ E = \frac{1}{2}mv^2 \]

Special relativity: \[ E = mc^2 = \frac{1}{2}mv^2 + mc^2 + \ldots \]

“Rest Energy” is there even when \( v = 0 \)

\[ \text{Mass to Energy} \]

\[ 4 \times ^1H \rightarrow ^4He + \text{neutrinos + energy} \]

\[ E = mc^2 \]

Mass of \(^4He\) = \(6.64648 \times 10^{-27}\) kg = \(6.64648 \times 10^{-27}\) kg

Mass of \(4 \times ^1H\) = \(4 \times (1.67353 \times 10^{-27}\) kg\) = \(6.69414 \times 10^{-27}\) kg

- Neutrinos have tiny mass
- ...so 0.007 x mass of H is converted to energy.

\[ 0.007 \times 2 \times 10^{30} \text{ kg} \times (3 \times 10^8 \text{ m/s})^2 = 10^{45} \text{ Joules (total available energy)} \]

\[ \text{(Available energy) / (Luminosity) = } \frac{1 \times 10^{45} \text{ J}}{4 \times 10^{38} \text{ W}} = \frac{1}{4} \times 10^{45-38} \text{ s} = 2.5 \times 10^{18} \text{ s} = 10^{11} \text{ years} \]

Actual number \(\sim 10^{10}\) yrs because Sun will evolve after central 10% of its mass is consumed, and then will die.