Special Relativity

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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.

➔ distance, time, velocity add up in funny ways

u = 70 mph → v = 100 mph →

Classical: $v' = (v-u)$

Special relativity: $v' = \dfrac{v-u}{1-\dfrac{uv}{c^2}}$

➔ Total energy of a particle moving at constant velocity v:

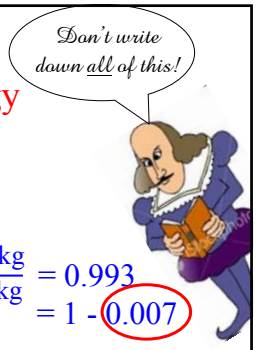
Classical: $E = \frac{1}{2} mv^2$

Special relativity: $E = \dfrac{mc^2}{\sqrt{1-v^2/c^2}} = \frac{1}{2}mv^2 + mc^2 + \ldots$

Kinetic energy

"Rest Energy" is there even when v = 0

Mass to Energy



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

$$E = mc^2$$

$$\frac{\text{Mass of } {}^4He}{\text{Mass of } 4 \times {}^1H} = \frac{6.64648\times10^{-27}\ \text{kg}}{4 \times (1.67353\times10^{-27}\ \text{kg})} = \frac{6.64648\times10^{-27}\ \text{kg}}{6.69414\times10^{-27}\ \text{kg}} = 0.993$$

$= 1 - 0.007$

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

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

  Mass of Sun; c^2

- (Available energy) / (Luminosity) = $\dfrac{1 \times 10^{45}\ \text{J}}{4 \times 10^{26}\ \text{W}} = \frac{1}{4} \times 10^{45-26}\ \text{s} = 2.5 \times 10^{18}\ \text{s}$

  $= 10^{11}$ years

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