

A muon is a subatomic particle with a rest mass of 1.88×10^{-28} kg and a half-life of 2.20 s. During an experiment moving muons are found to have a half-life of 15 s.

- a) What is the velocity of the muons?

Time dilation is occurring and the Lorentz factor is

$$t' = \frac{t}{\gamma}$$

$$\gamma = \frac{t}{t'} = \frac{15.0\text{s}}{2.20\text{s}} = 6.82$$

$$\gamma = \frac{1}{\sqrt{1 - (v/c)^2}}$$

With algebra find velocity

$$\gamma^2 = \frac{1}{1 - (v/c)^2}$$

$$\frac{1}{\gamma^2} = 1 - (v/c)^2$$

$$\frac{v}{c} = \sqrt{1 - \frac{1}{\gamma^2}}$$

$$v = c \sqrt{1 - \frac{1}{\gamma^2}} = c \sqrt{1 - \frac{1}{6.82^2}} = 0.989 c$$

- b) What is the momentum of the muons?

The relativistic momentum equation gives

$$p = \gamma mc = 6.82(1.88 \times 10^{-28} \text{ kg})(3.0 \times 10^8 \text{ m/s}) = 3.85 \times 10^{-19} \text{ kg} \cdot \text{m/s}$$