178.

Problem 2.29 R (29)

The lifetime of muon (μ) stopped in a lead block in the laboratory is measured to be 2.3×10^{-6} s. The mean lifetime of high-speed muons in a burst of cosmic rays observed from the earth is measured to be 1.6×10^{-5} s. We have to find the speed of the cosmic ray muons.

Solution:

The lifetime of muon as measured in the laboratory by observing stopping time in a lead block is $t_0 = 2.3\times10^{-6}$ s. This will be the proper time as in a lead brick muon will be moving with non-relativistic speed. The lifetime of high-speed muons produced in a cosmic ray burst as measured from the earth is $t = 1.6\times10^{-5}$ s. Let the speed of these high-speed muons measured from the earth be v m s^{-1}.

We have

$$\frac{t_0}{t} = \sqrt{1 - v^2/c^2}.$$

We therefore have

$$1 - \frac{v^2}{c^2} = \left(\frac{2.3 \times 10^{-6}}{1.6 \times 10^{-5}} \right)^2,$$

or

$$\frac{v^2}{c^2} = 1 - 0.0206 = 0.979,$$

and

$$v = c \times (0.979)^{1/2} = 0.99 \; c.$$