B. Sc. Part I
Paper I

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Theory of Relativity

Example of time dilation :-

Imagine that once a 40 years old Scientist fell in love with his 16 years laboratory assistant. They want to marry; but They feel that Their Marriage cannot be welcomed by The society due to The age difference. Scientist plans to marry using The principle of time dilation of relativity. He synchronises his clock with That of his assistant and goes to a long space journey in a spaceship moving with velocity 0.999c. He returns back when his clock reads one year and reads the clock of his assistant. He finds that in here clock

$$\left[\Delta t' = \frac{\Delta t}{\sqrt{(1 - v^2/c^2)}} = \frac{1}{\left\{\sqrt{\left(1 - \frac{0.999c}{c}\right)^2}\right\}} = 22.7 \text{ year}\right]$$

have passed. This means that now scientist is 41 years old and his assistant $(16 + 22.7) = 38.7$ years old. Their age difference barrier has now been overcome, so they marry reciting The limerick:

" There once was a lady called Bright,
who could travel faster than light;
She went out one day, in a relative way
And came back the previous night."

Date

Expt. No. An experimental verification of time dilation:

To observe the time dilation in the laboratory, the following conditions must be fulfilled:

1.) The bodies must move with speed v which is not negligible with that of light.

2.) The events occuring in these bodies at intervals should be independent of v.

3.) The time interval between the events should be sufficiently short so that the events may occur within a reasonably short travel of bodies; otherwise the 'laboratory' necessary will be inconveniently long.

Some nuclear and elementary particles satisfy these conditions, they undergo some transformations with a proper life time τ which is independent of their speed and they can be produced with sufficiently large speeds, so that their non-proper life time τ' (measured in the laboratory frame) may differ appreciable from τ.

The nuclear particles, called π^{*} mesons, are produced with speed $0.99c$ when high energy particles generated by a synchrotron strike a target. These mesons decay (break into μ mesons and neutrinos) in such a way that in every 1.8×10^{-8} second half of them die out. The flux of these π^{*} means was measured at two places separated by 30 metres. The laboratory time interval $\Delta t'$ for travelling the distance was given by

$$\Delta t' = \frac{30\,m}{0.99 \times 3 \times 10^{8}\,m/sec} = 10 \times 10^{-8}\,sec$$

Teacher's Signature

This is about 5-6 times of 1.8×10^{-8} sec.
Hence The flux of π^+ mesons should decrese to 2^{5-6} or less Than 2% of The original flux in travelling 30 metres. But The actual flux at The Second place was = 60% of That at The first place. This discrepancy is explained by calculating the proper time Δt by The relation

$$\Delta t' = \frac{\Delta t}{\sqrt{(1-v^2/c^2)}}$$

or $\Delta t = \Delta t' \sqrt{\left(1-\frac{v^2}{c^2}\right)} = 10 \times 10^{-8} \sqrt{\left\{1-\left(\frac{0.99c}{c}\right)^2\right\}}$

$$= 10 \times 10^{-8} \sqrt{[1-(0.99)^2]} = 1.4 \times 10^{-8} \text{ sec}$$

This is 0.78 times of 18×10^{-8} sec. Hence in This much time The flux should fall to $2^{-0.78}$ (Nearly 60%) This is exactly what is observed.

From This experiment it is clear That in The laboratory Measurements the time taken by π^+ mesons for 30 metres travel is 10×10^{-8} sec, while π^+ mesons Themselves measures the time as 1.4×10^{-8} sec. Thus a 7-fold time dilation has occured in This case.