**UNIT 3 Special Theory of Relativity:**

1. Explain the Michelson Morley experiment.
2. Derive Lorentz transformation equation and discuss the significance.

**Students,** The derivation of Lorentz transformation equation given below is different from the derivation discussed in video lecture.

Q. 2 Derive the Lorentz transformation equation:

Lorentz made some corrections in **Galilean transformation.** He suggested that in Galilean transformation the inter-relationship between x (**stationary frame**) and x’ (**moving frame with velocity comparable to c** i.e. v~c) is proportional with some constant ***k***. where k is independent of x & t. therefore

As the law of physics must have the same form in both S and S’ therefore, to find the co-ordinate for an observer in S, we interchange the position of co-ordinate and sign of *v* in (1).

Substituting (1) into (2)

………………….(3)

It shows that *t* and *t’* are not equal. Time is also frame dependent.

According to Einstein’s second postulate, speed of light should be same in S and S’

Therefore, a flash of light observed by an observer in S’ frame

And the same observed by an observer in Sframe

Now substituting value of x’ (eq. 1) and *t’* (eq. 3) into (4)

Equating above expression with equation (5) we find that bracketed value should be equal to 1

Thus we are able to determine the value of constant k:

Evaluation

**Evaluation of time t:**

To simplify the calculation in equation (3) we take the value of from equation (6):

Substituting above in equation (3)

On substituting the value:

Substituting the value of k, we get the relation between time *t’* and *t* such that:

Substituting the value of k into equation (1), we get the relation between time x’ and x such that:

Above mention relations are known as ***Lorentz transformation relations***.

**Q. 3 Addition of velocities (relativistic case).**

**Differential of**

* **Lorentz transformation equations:**

Later, to remove the discrepancy in MM experiment, the Lorentz scientist established new set of transformation equations called **Lorentz transformation equation.** Lorentz made some corrections in **Galilean transformation.** He suggested that in Galilean transformation the inter-relationship between x (**stationary frame**) and x’ (**moving frame with velocity comparable to c** i.e. v~c) is proportional with some constant ***k***. where k is independent of x & t.

The value of ‘k’ was found as

When a particle travels with velocity v comparable to c (means at relativistic speed) then the value of ‘k’ is always less than 1.

**k < 1** for relativistic particle and

**k = 1** for non- relativistic particle

**Lorentz transformation equations**

Above shows that if a frame (body) is moving at relativistic speed then at any instant ‘t’ the position measured by an observer i.e. x and the position measured by an observer in moving frame i.e. x’ are not same and their interrelationship is mentioned above.

Similarly, time measured in stationary frame (t) and in moving frames (t’) are not same. Their interrelationship is mentioned above.

Hence, for relativistic particles above relations are used.

**Addition of velocities of relativistic particles (frames).**

Similarly, the velocities measured in stationary frame (vx) and in moving frames(v’x) are related as mentioned above.

**Numerical problems:**

1. Two particles are moving in opposite directions each with speed of 0.8c in laboratory frame of reference. Find the velocity of one particle relative to other.

[Hint: for moving frame observer (frame S’) and for stationary frameobserver (frame S’)  **.** Here ***vx = v* ]**

1. An experimenter observes a radiative atom moving with a velocity of 0.26c. The atom then emits beta particle which has a velocity of 0.9c relative to the atom in the direction of it motion. What is the velocity of the beta particle as observed by the experimenter?