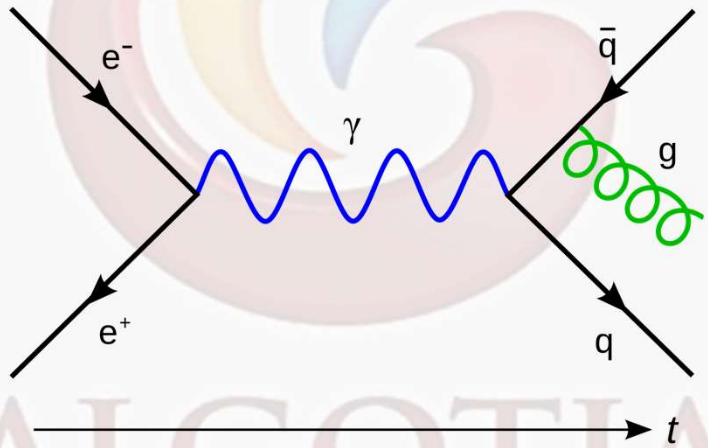
School of Basic and Applied Sciences

Course Code : MSCP6001 **Course Name: ELECTRODYNAMICS**

Electrodynamics



Name of the Faculty: Dr. ASHUTOSH KUMAR **Program Name: M.Sc. Physics**

Topic Covered

- Time Dilation
- Fitzgerald Contraction
- Some reminders
- Spacetime diagrams
- References

Time Dilation

Let's again consider two observers, A&B. To simplify the problem, we only consider x-directional motion.
Let's have A sit still in some jet moving with const. velocity v in the +x direction w.r.t B, then,

For A, she would observe herself only traversing in time, therefore,

$$\mathrm{ds}^2{}_A = -c^2\mathrm{dt}^2$$

As for B, he would observe the interval as

$$\mathrm{ds}^2{}_B = -c^2\mathrm{dt}'^2 + v^2\mathrm{dt}'^2$$

Assuming intervals are invariant, (we haven't proven that the invariance of intervals gives the correct Lorentz transforms yet) $\mathrm{ds}^2{}_A = \mathrm{ds}^2{}_B$

This then gives

$$\mathrm{dt}' = \frac{\mathrm{dt}}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \equiv \gamma\mathrm{dt}$$

Which is the time dilation formula.

Fitzgerald Contraction

sure for us v'. Seeing that our clocks tick more slowly, but knowing that our speed is still v', the people in the other spaceship conclude that in our reference frame, our spaceship must have traveled only a distance

$$\Delta\ell = v'\,\Delta t = \frac{v'\,\Delta t'}{\gamma'} = \frac{\Delta\ell'}{\gamma'} \tag{6.45}$$

in the time interval Δt that we measure. So, to the other space travelers, it looks as if our distances are all shorter by a factor of $1/\gamma'$. This is called the FitzGerald contraction, after the Irish physicist George FitzGerald, who proposed this process in 1889. Of course, from our point of view, our distances have not changed.

Some reminders

Postulates of special relativity:

1. The laws of physics are the same in all inertial frames of reference

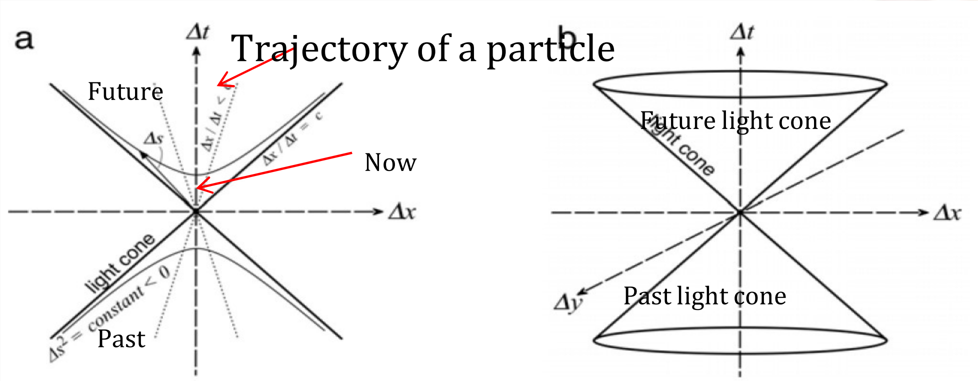
2. The speed of light in free space has the same value c in all inertial frames.

On the Minkowski metric:

$$(6.41)\ \mathrm{d}s^2 = -c^2\,\mathrm{d}t^2 + \mathrm{d}x^2 + \mathrm{d}y^2 + \mathrm{d}z^2$$

1. It works for observers moving at any speed up to c.
2. Equation (6.41) is the same for travelers moving at different speeds.
3. It is an extension of the Euclidean metric, although definitely not simply four-dimensional Euclidean.
4. The true fabric of the universe includes both space and time.

Spacetime diagrams



Any event that you can affect lies in your future light cone.

Any event that has the chance of affecting you at this very moment lies in your past light cone.

$ds^2 < 0$ timelike intervals
$ds^2 > 0$ spacelike intervals
$ds^2 = 0$ lightlike intervals

References

- D.J. Griffiths, Introduction to Electrodynamics,4th ed.,Pearson, USA, 2013.
- J.D. Jackson, Classical Electrodynamics, 3rd ed.,New Age, New Delhi, 2009
- R.K. Patharia ,Theory of Relativity, 2nd ed, Hindustan Pub., Delhi, 1974.
- I.R. Kenyon, General Relativity, Oxford Univ. Press, 2001.
- J.B. Marion and M.A. Heald, Classical Electromagnetic Radiation , 3rd ed., Saunders college Publishing House, 1995.