Modern Physics PHYS 351 — "Summery of Relativity I"

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Postulates of special relativity

The two basic postulates of the special theory of relativity are as follows:

First The laws of physics must be the same for all observers moving at constant velocity with respect to one another, i.e. in all inertial frames.

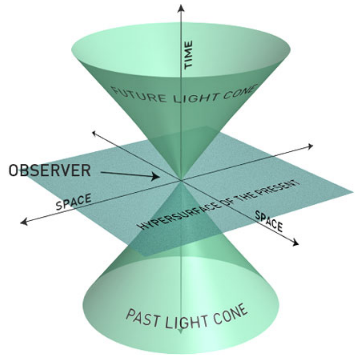
Second The speed of light c is the maximum speed in the universe, and it is constant for all inertial frames.

Spacetime

To accommodate with the previous postulates, we must think of time are a coordinate, like the space, not as a fixed clock. Introducing the notion of ' spacetime'. A four dimensional space with the forth coordinates being ict, called the Minkowski space. A point in Minkowski space is called an event, the length of a vector in that space denotes a physical law, hence all inertial observers much agree on it. We also introduce the notion of a light-cone denoting how events are causally connected to an observer at rest centred at the origin.

Lorentz Transformations

Lorentz transformation are transformations of coordinates in Minkowski space that keeps the length of a vector there constant. Hence they satisfy the postulates of special relativity. And in one spatial dimension they are



given by ' boost transformations'

$$x' = \gamma\,(x - vt) \quad (1)$$
$$y' = y \quad (2)$$
$$z' = z \quad (3)$$
$$t' = \gamma\left(t - v/c^2 x\right) \quad (4)$$

Where γ is the Lorentz factor

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \quad (5)$$

We can also define Lorentz transformations from relative velocities

$$u'_x = \frac{u_x - v}{1 - \frac{u_x v}{c^2}} \quad (6)$$
$$u'_y = \frac{u_y}{1 - \frac{u_x v}{c^2}} \quad (7)$$
$$u'_z = \frac{u_z}{1 - \frac{u_x v}{c^2}} \quad (8)$$

Consequences of special relativity

A consequence for Lorentz transformations are the Fitzgerald contraction of Length and time dilation:

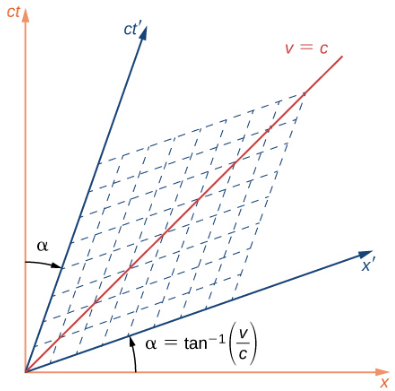
$$L = \frac{L_0}{\gamma} \tag{9}$$

$$\Delta t = \gamma \Delta t_0 \tag{10}$$

Moreover, Events that are simultaneous for one observer are not simultaneous for another observer in motion relative to the first.

Lorentz boosts as rotations in the ct-x plane

One can think of transforming from a rest frame F to an inertial frame F' moving at velocity v relative to the rest frame. As a rotation of the spacetime plane as in the figure The rotation looks deformed because the Minkowski



space is different from the Eucleadian space.

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