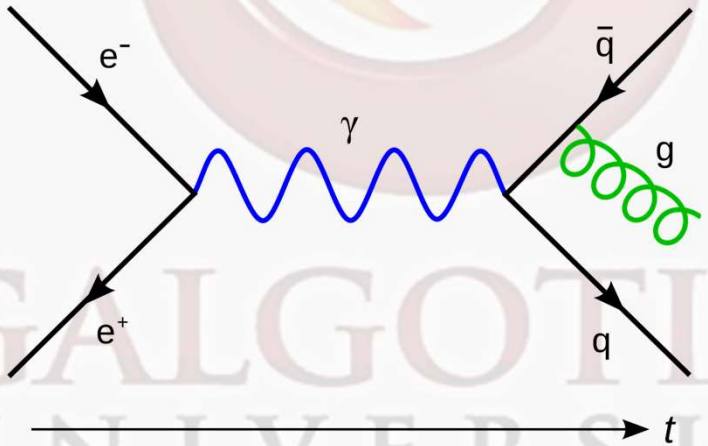
Electrodynamics

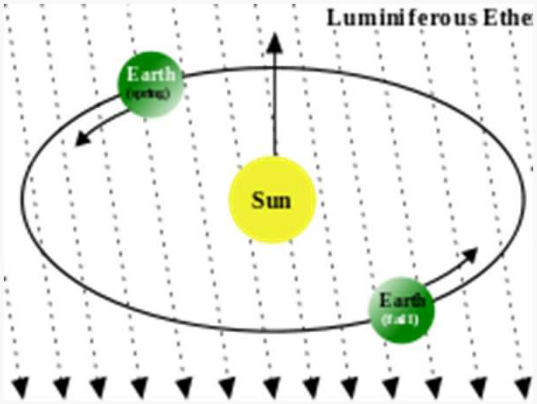
Topic: Introduction



Topic Covered

- Space and time
- Historical notes
- The line element in spacetime
- A twist in ideas
- References

The need to rethink space and time



Any such beam of any kind of particles generated at the speed of light by a moving observer would be received by a stationary observer at that same speed – regardless of how fast the two observers were moving relative to one another.

How could the old Galilean view of space and time work to explain this?

Note: the Lorentz transformations came way before this deeper insight of geometry started to take hold.

A note of history

The views of space and time which I wish to lay before you have sprung from the soil of experimental physics, and therein lies their strength. They are radical. Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality. – Hermann Minkowski, 1908

The line element in spacetime

Previously, in 3D Euclidian geometry, we learned that $dl^2 = dx^2 + dy^2 + dz^2$ is invariant under coordinate transformations.

Considering space and time together and taking into account that the speed of light must be constant in any frame, we find that the *new* line element to satisfy such conditions is

$$ds^2 = -c^2\,dt^2 + dx^2 + dy^2 + dz^2$$

Verification :

Let a photon travel along the x direction. Given that we have two observers (A&B) with different velocities along the x axis,

For A, the line element is then $ds^2 = -c^2\,dt'^2 + c^2 dt'^2 = 0$
For B, the line element is still $ds^2 = -c^2\,dt^2 + c^2 dt^2 = 0$

This is because both of them see the photon traveling at c !

An interesting fact about this is that photons apparently travel along what is called null geodesics, the line elements are 0 in any frame !

A twist in ideas

One other interesting property that follows directly by considering the following line element

$$ds^2 = -c^2\,dt^2 + dx^2 + dy^2 + dz^2$$

Is that even when we are apparently sitting still, given that some time dt has elapsed, then we have already traveled by an interval square of $ds^2 = -c^2\,dt^2$!

So much for 'common sense' of 'not moving' !

Based on the idea of line elements, we must also be able to derive the findings using pure algebra as were first during the development of special relativity.

Namely, we should derive:

1. The effect of Time Dilation
2. The effect of FitGerald Contraction (or Lorentz Contraction)
3. The Lorentz Transforms

References

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