Timepix3 in the AEgIS experiment

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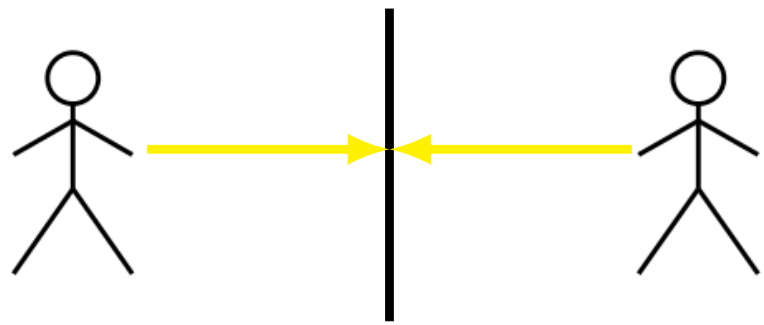
Special relativity

- Unsolved problems at that time
  - What is the speed of light
  - Maxwells equations not consistent with relative speed of light in eter
- Postulates
  - Laws of physics is the same in all reference frames
  - Speed of light is constant
- Groundbreaking new ideas
  - Space and time is not independent
  - Simulationous depends upon reference frames



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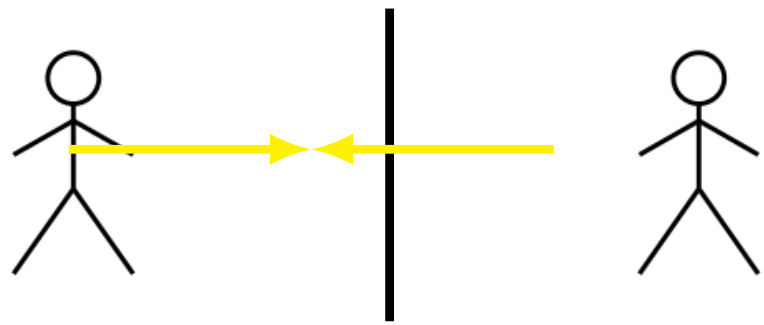


Special relativity

By assuming the two postulates the Lorentz transformation for special relativity was derived in 1905

$$t' = \beta(t - vx/c^2)$$
$$x' = \beta(x - vt)$$
$$y' = y$$
$$z' = z$$

where :

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

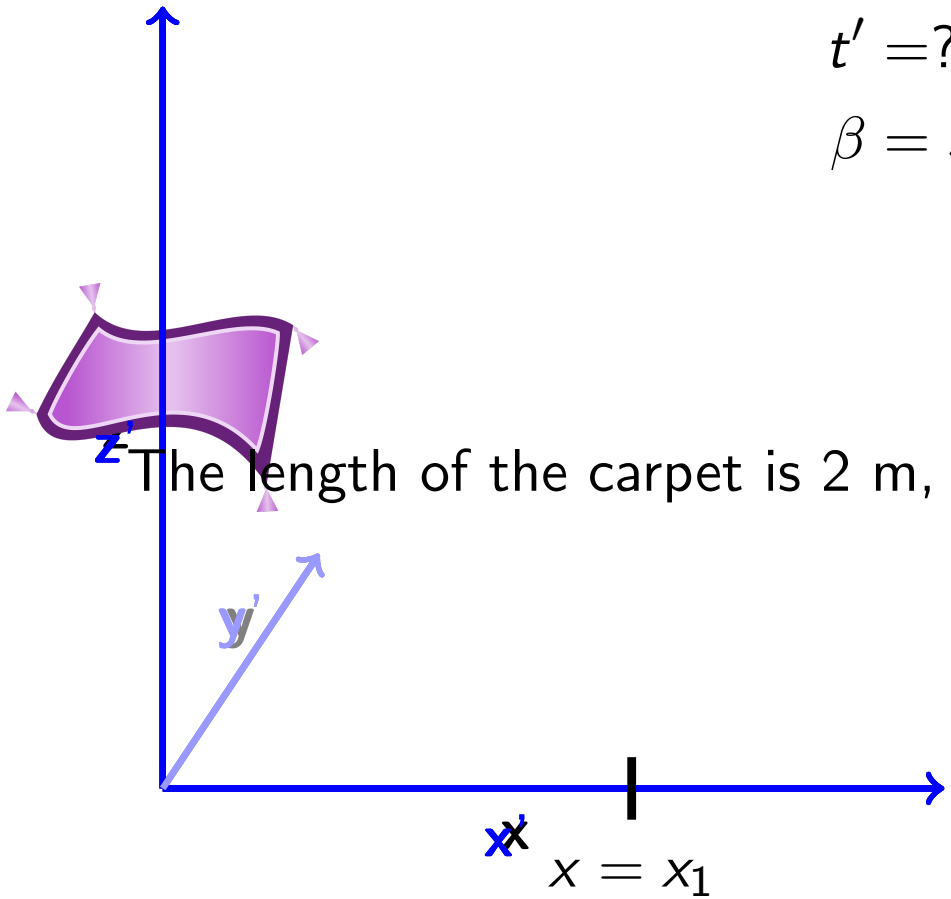
Length contraction and time delation

$$v = 0.99c$$

$$x_1 = vt$$

$$t' = ?$$

$$\beta = 50$$



The length of the carpet is 2 m, what is the length as seen by us

Length contraction and time delation

$$v = 0.99c$$

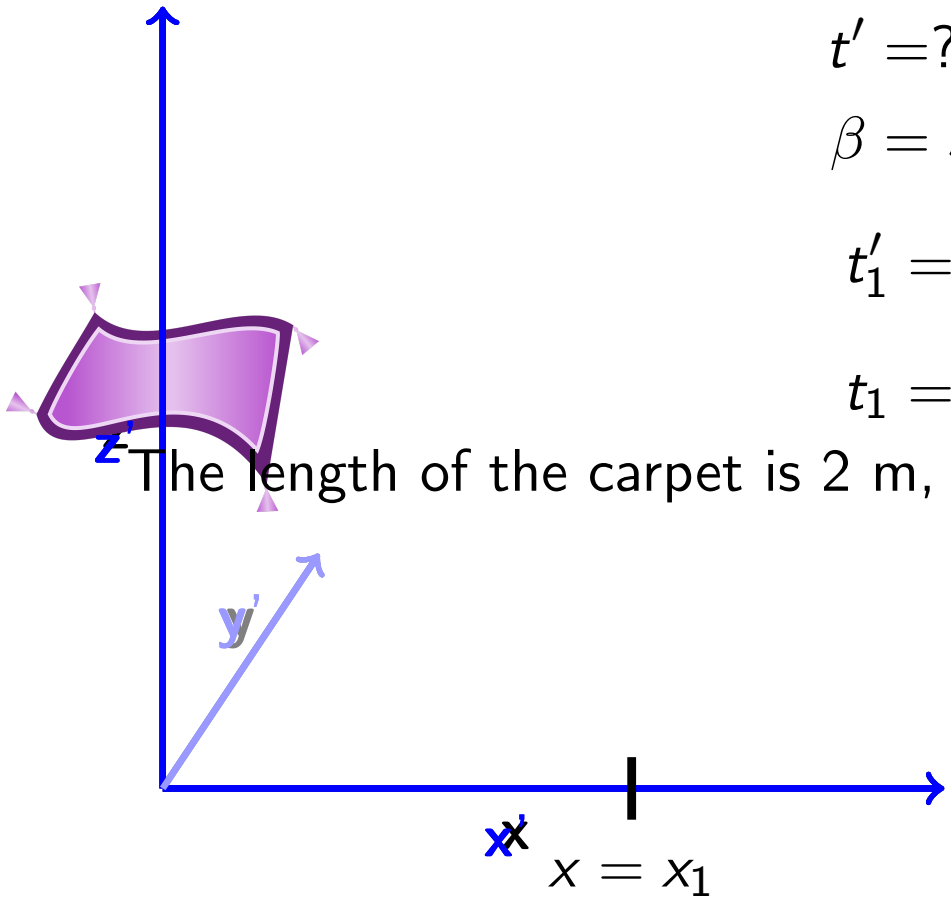
$$x_1 = vt$$

$$t' = ?$$

$$\beta = 50$$

$$t_1' = \frac{t_1}{\beta}$$

$$t_1 = \beta t_1'$$



The length of the carpet is 2 m, what is the length as seen by us

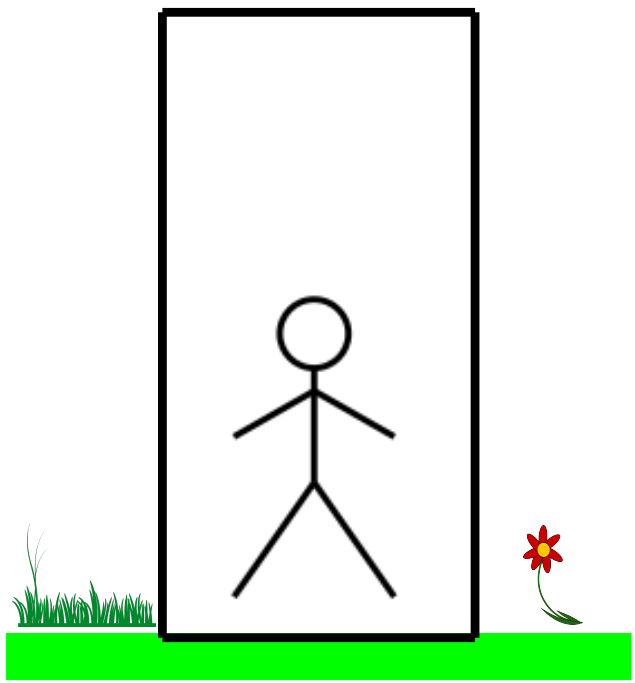
Particle accelerators

Without time delation, the particles themself experience the time to be shorter from one end of the accelerator to the other or that we see them as taking longer time. Therefore the bunch of electrones, as you see here in CLEAR would blow up much more and not be useful in the end

General relativity

Is gravity accelration

- In 1907 Einstein had the "happiest thought of his life"
- There is no difference between being in an elevator in space or being in a gravitational field
- This was a continuation of the the universiality of free fall



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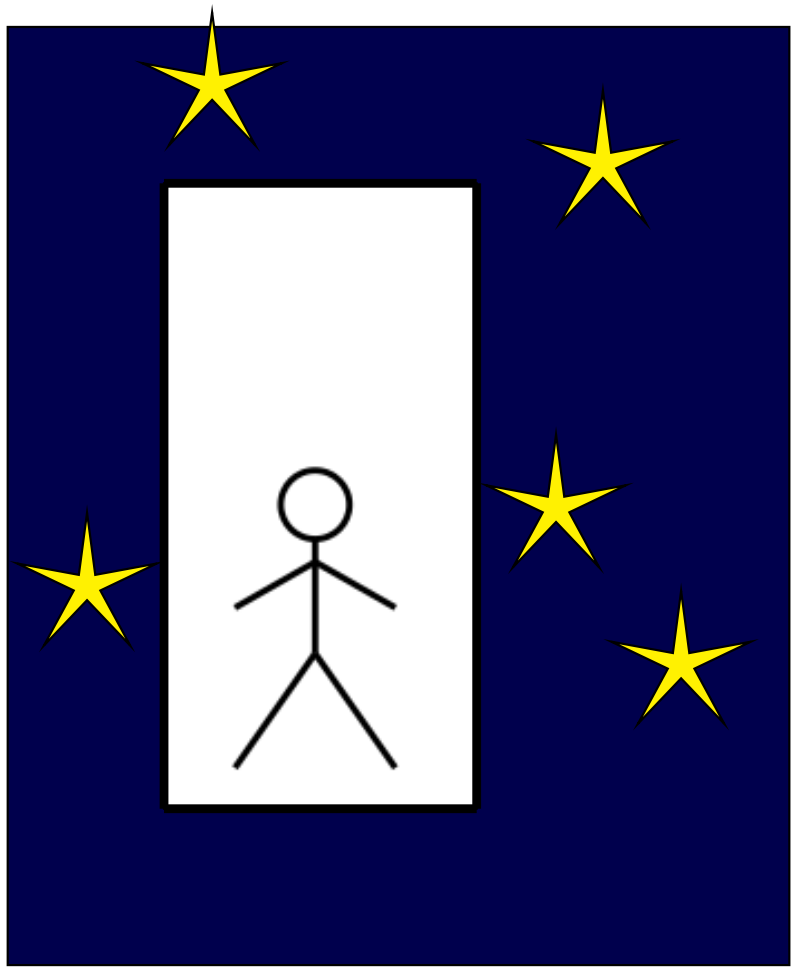
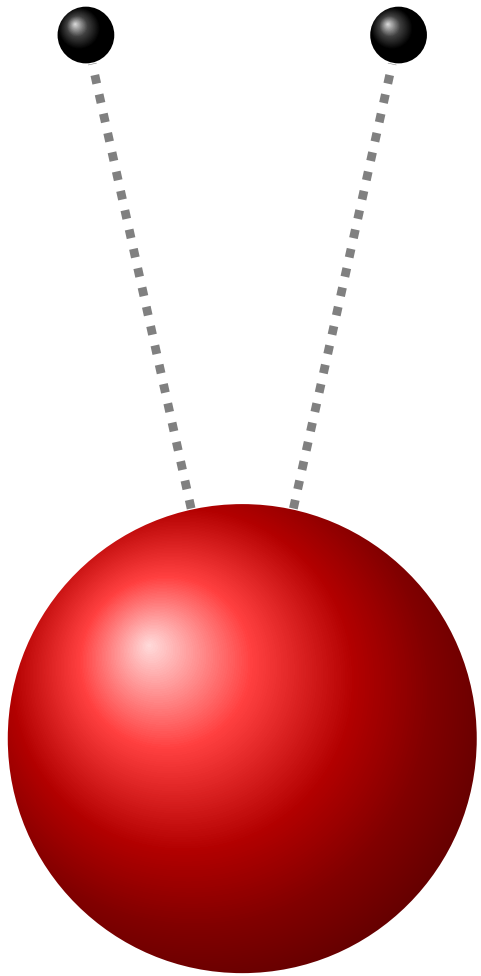


Is gravity a geometrical effect

- The equivalence principle is only valid locally
- Globally there is tidal forces
- Can gravity be a geometrical effect



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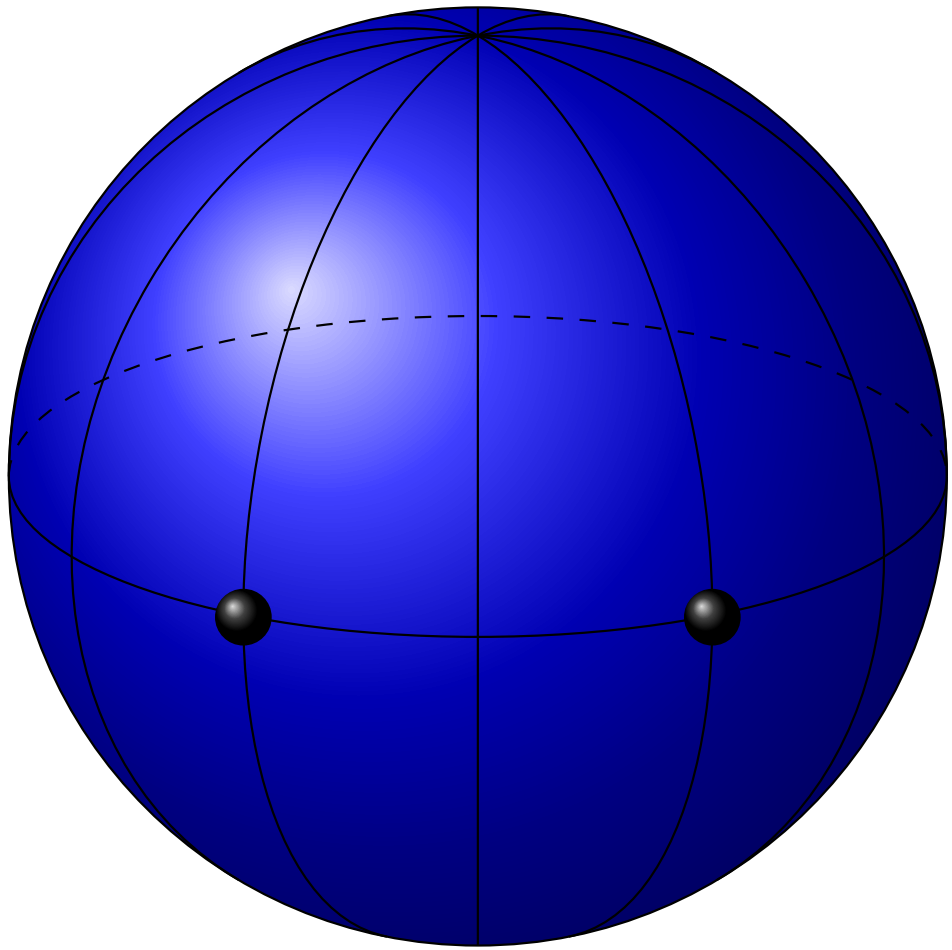

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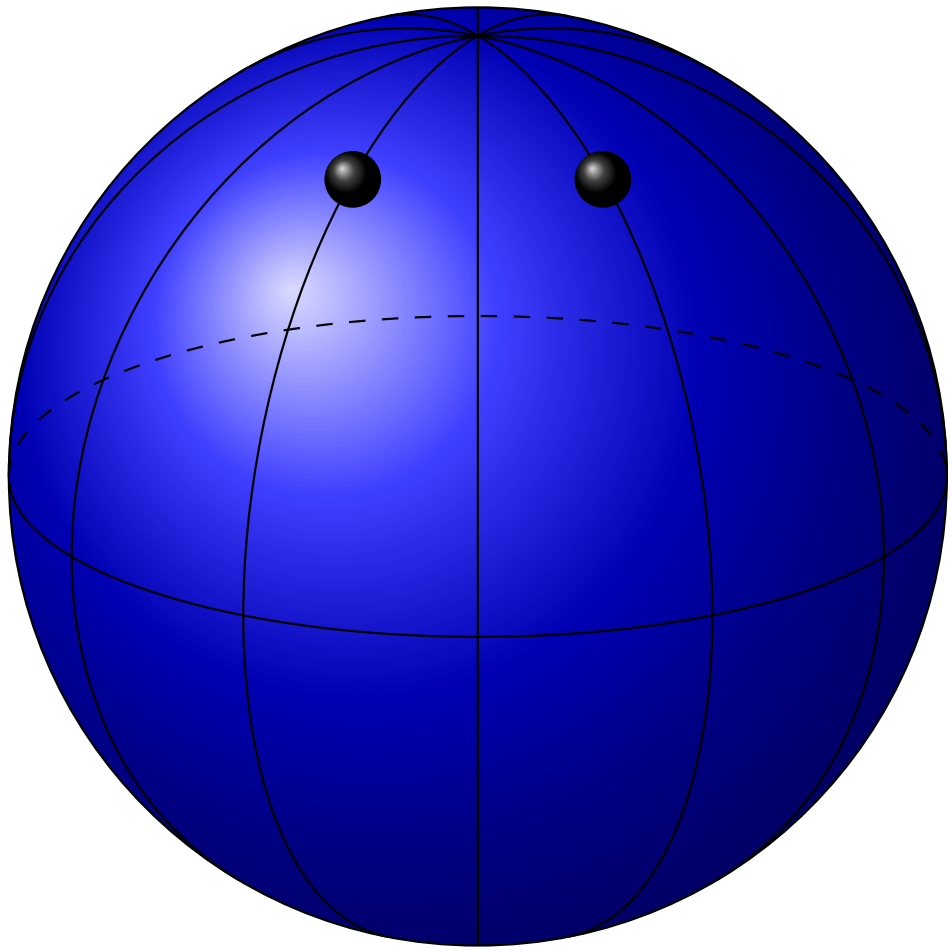

A geometrical model for gravity

- A manifold is a space that is curved, but locally in one point flat
- The surface of a sphere is a manifold
- General relativity describes space as a manifold
- Locally it can be described as a free falling coordinate system, the weak equivalence principle holds
- Describing space as a manifold gave the theory a mathematical framework, namely the mathematics of tensor analysis

Einsteins field equations

- By describing space by this manifold, and requireing that Newtons mechanics holds for low energies the Einstein field equation was derived
- Left side of the equation describes the curvature of space, metric $g_{\mu_n u}$
- The metric is the input to the geodesic equation, that gives the paths objects will move if no force is acting
- Λ is the cosmological constant
- $T_{\mu\nu}$ is the stress-energy

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + g_{\mu\nu}\Lambda = \frac{8\pi G}{c^4} T_{\mu\nu}$$