Imperial College London

Relativity – Lecture 4

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Key concepts of lecture 3

- Events that are simultaneous in one inertial frame and spatially separated, are non-simultaneous in another inertial frame.
- Time dilation: moving clocks run slow.
- Proper time: the time interval measured between 2 events by a stationary clock.
- Length contraction: moving objects are short.

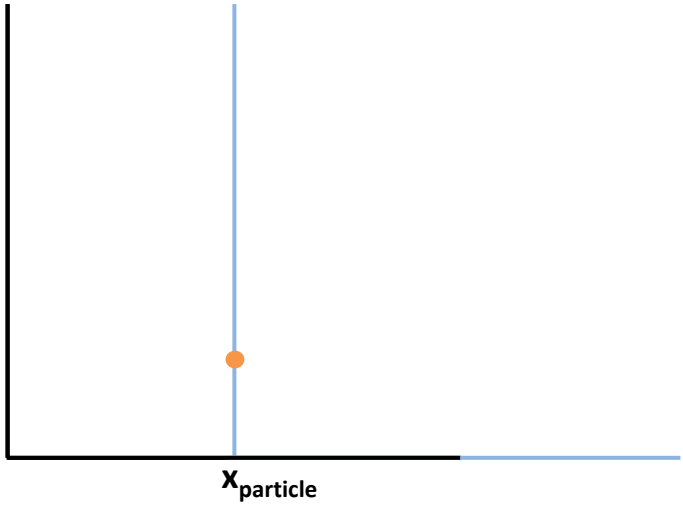
Example: time dilation & length contraction

A negatively-charged pion (π^-) travels at $\beta = 0.998$ in a lab. It's lifetime is measured in the lab frame to be 4.20×10^{-7} s.

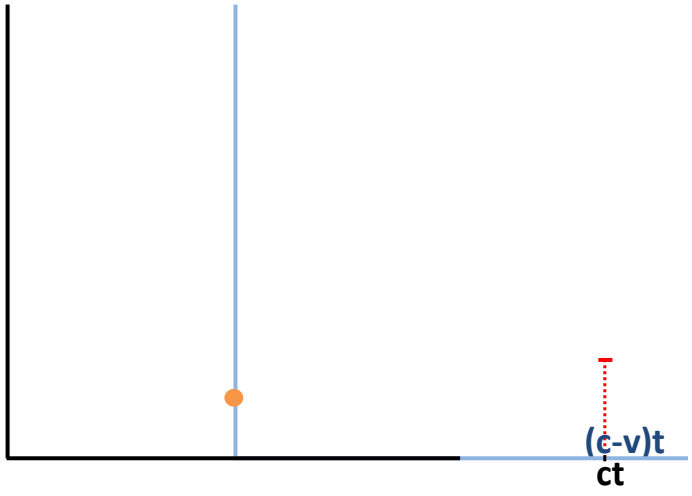
1. What distance does it travel in the lab frame?
2. What distance does it travel in the pion's rest frame?
3. What is its rest frame lifetime?

Example: time dilation & length contraction

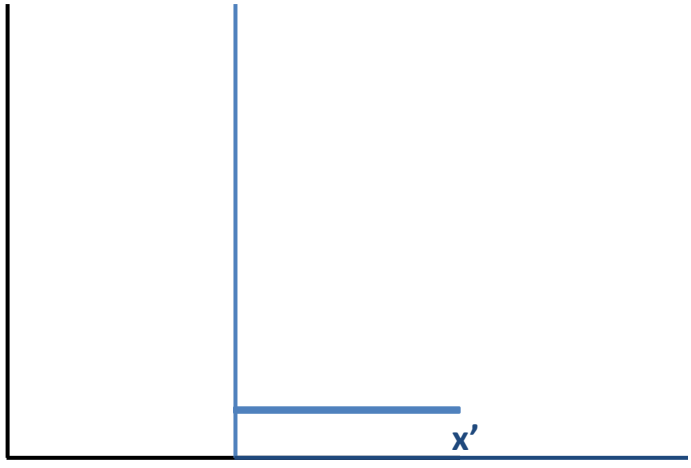
Galilean coordinate transformation



Galilean transformations: what about light?



Lorentz transformations



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Lorentz transformations

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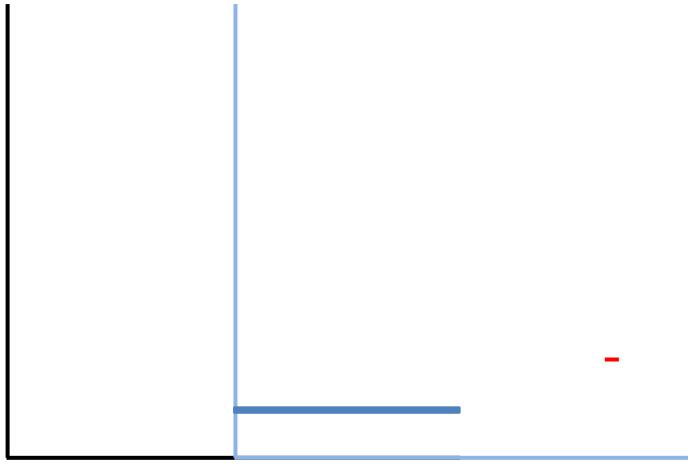
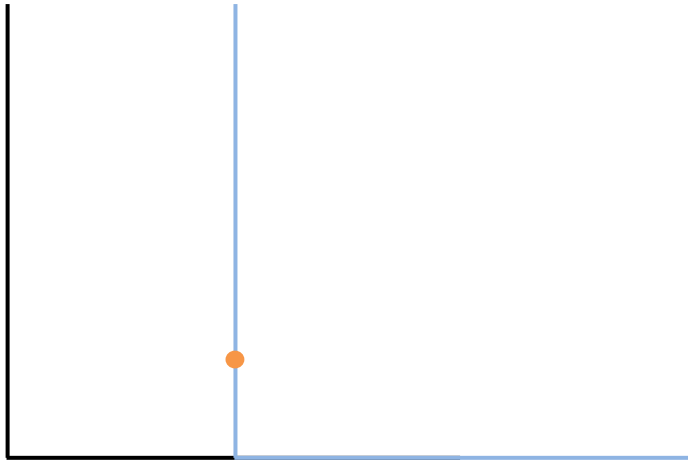
Lorentz transformations: what about light?



Example: Lorentz transformations

Velocity Addition



Example: velocity addition

Summary of formulae

Lorentz transformations (1D):

$$x' = \gamma(x - vt)$$
$$y' = y$$
$$z' = z$$
$$t' = \gamma(t - \frac{vx}{c^2})$$

Velocity addition:

$$u' = \frac{u-v}{1-\frac{uv}{c^2}}$$