양자역학의 기초

이 병 호
서울대 전기공학부
byoungho@snu.ac.kr
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Nothing to Do?

"It seems probable that most of the grand underlying principles have been firmly established and that further advances are to be sought chiefly in the rigorous application of these principles. ... The future truths of Physical Science are to be looked for in the sixth place of decimals." – Albert A. Michelson in 1894

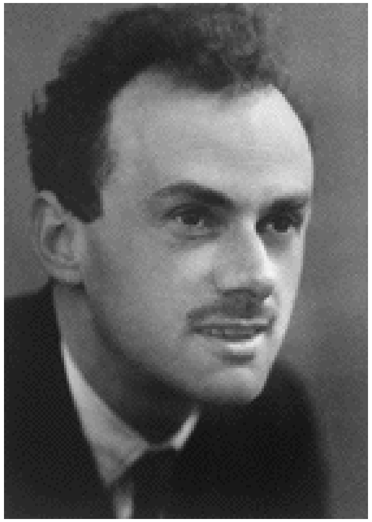
The 20th Century

“It was a marvelous time to be alive.”

– Albert Einstein

Quantum Mechanics

"양자역학은 물리의 대부분과 화학의 전부를 설명."
– Paul A. M. Dirac (1902–1984)



Do We Need to Know?

As electrical or electronic engineers, do we need to know QM?

No and Yes!

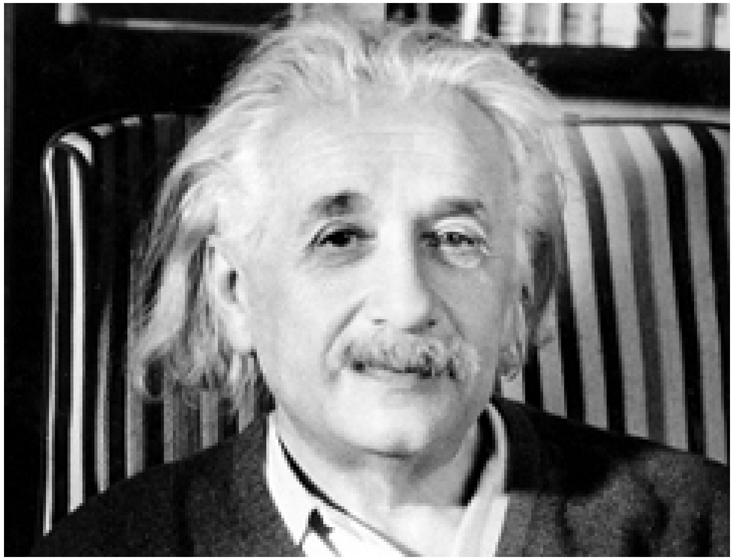
Is QM Hard to Learn?

Is the Quantum Mechanics difficult to understand?

No (in general) and yes in some details.

Ch. 1. Relativity I

The King



Albert Einstein (1879-1955)

World Year of PHYSICS 2005

www.physics2005.org

1905

Young Einstein at the Swiss Patent Office in Berne

Annalen der Physik, vol. 17 (1905)

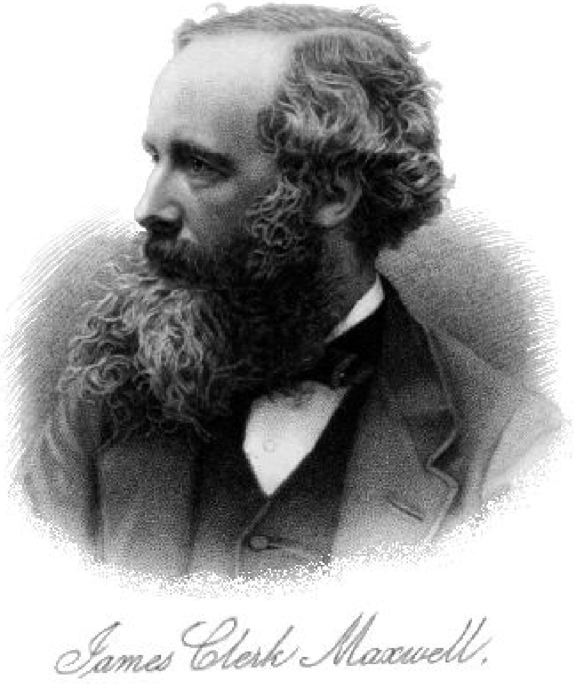
“one of the most remarkable volumes in the whole scientific literature. It contains three papers by Einstein, each dealing with a different subject and each today acknowledged to be a masterpiece.” – Max Born

Abraham Pais, whose biography of Einstein is the best of the many written, leaves us with this glimpse of Einstein about three months before he died in 1955. He had been ill and unable to work in his office at the institute. Pais visited him at home and ...

"went upstairs and knocked at the door of [his] study. There was a gentle "Come." As I entered, he was seated in his armchair, a blanket over his knees, a pad on the blanket. he was working. He put his pad aside at once and greeted me. We spent a pleasant half hour or so; I do not recall what was discussed. Then I told him I should not stay any longer. We shook hands, and I said goodbye. I walked to the door of the study, not more than four or five steps away. I turned around as I opened the door. I saw him in his chair, his pad on his lap, a pencil in his hand, oblivious to his surroundings. He was back at work.

– *From "Great Physicists"*
by W. H. Cropper

Electromagnetic Fields



Michael Faraday (1791–1867)

James Clerk Maxwell (1831–1879)

Electromagnetic Wave

Wave equation

$$\nabla^2 \mathbf{E}(\mathbf{r},t) - \frac{1}{c^2}\frac{\partial^2 \mathbf{E}(\mathbf{r},t)}{\partial t^2} = 0$$

$$c = \frac{1}{\sqrt{\mu_o \varepsilon_o}} \approx 3\times 10^8 \text{ m/s}$$

with respect to what?

Michelson Interferometer

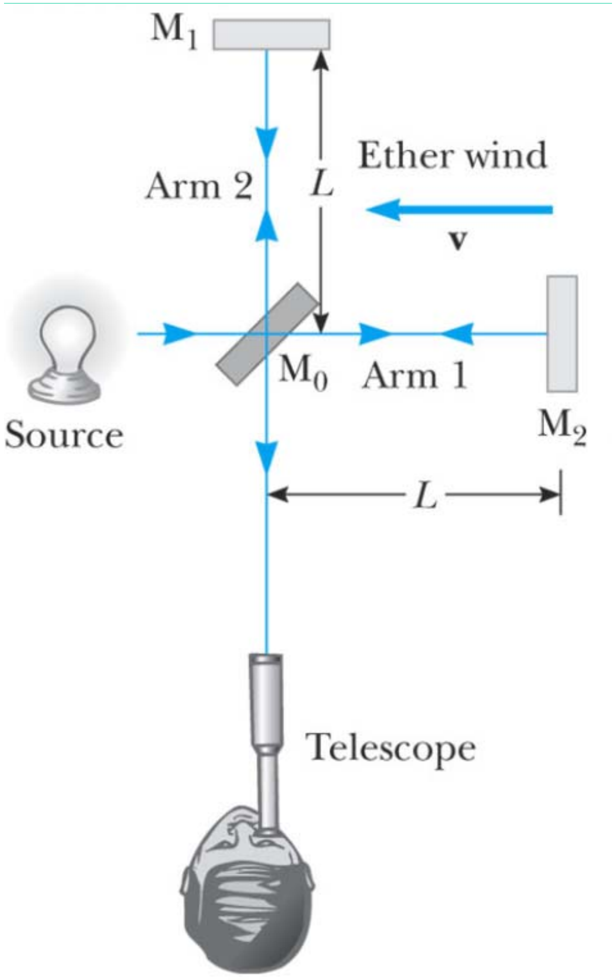


Fig. 1-4, p. 8

Special Relativity

Two postulates:

- The Principle of Relativity

  All the laws of physics have the same form in all inertial reference frames.

- The Constancy of the Speed of Light

  The speed of light in vacuum has the same value in all inertial frames, regardless of the velocity of the observer or the velocity of the source emitting the light.

Different Inertial Frames

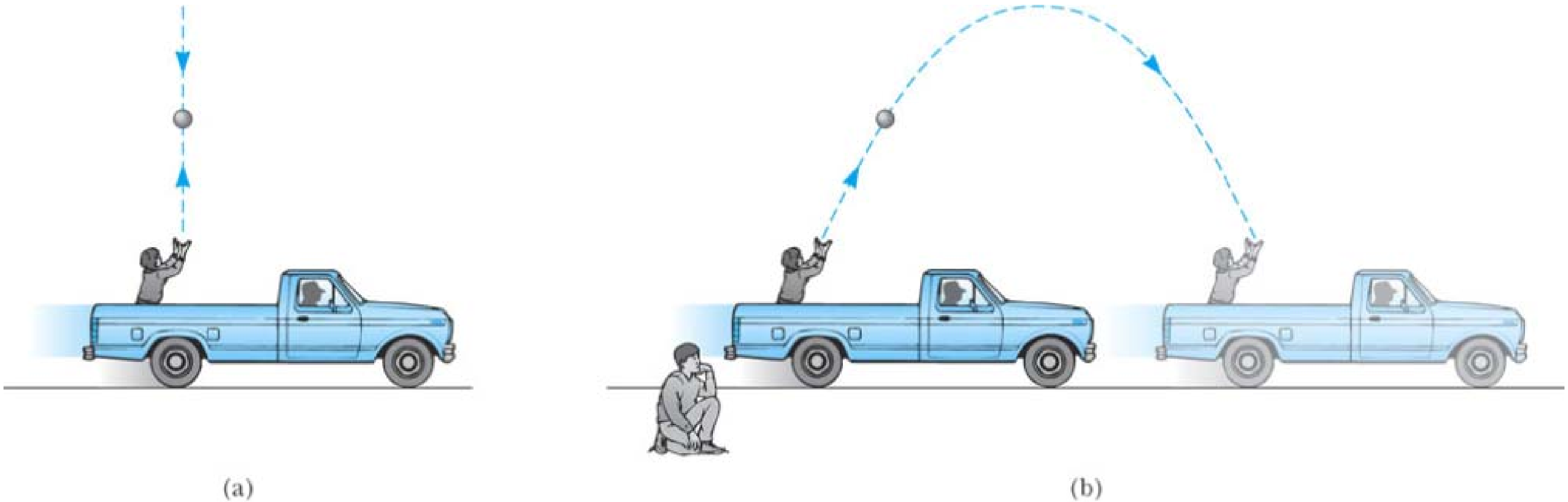
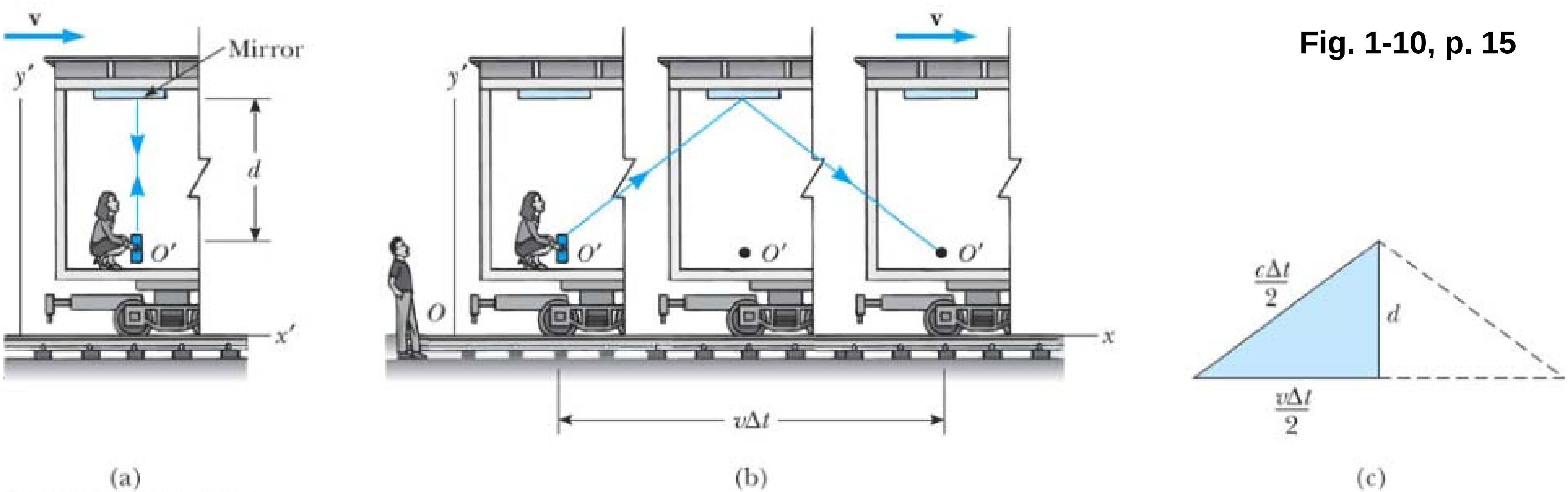


Fig. 1-1, p. 4

Time Dilation

Fig. 1-10, p. 15



$$\Delta t = \frac{\Delta t'}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma \Delta t'$$

Length Contraction

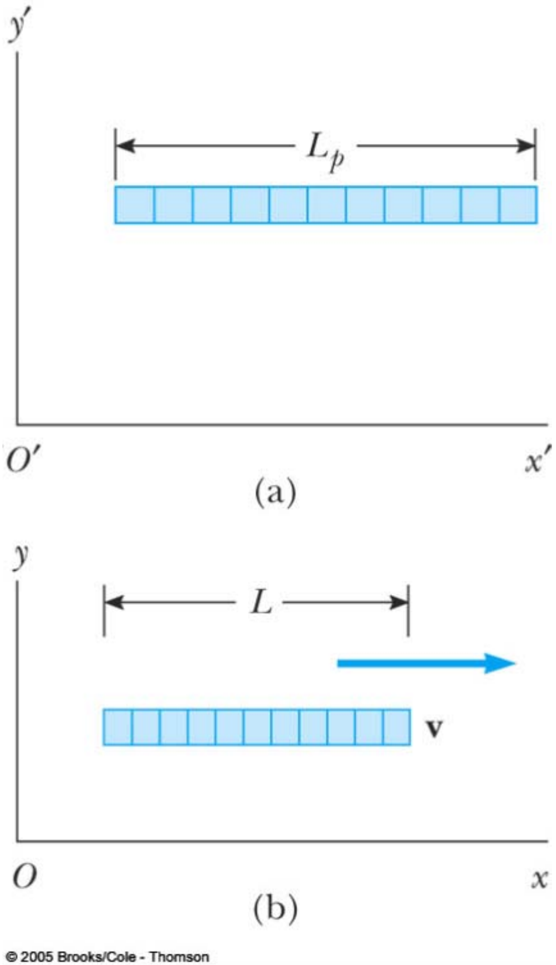


Fig. 1-13, p. 19

$$L = L_p \sqrt{1 - \frac{v^2}{c^2}}$$

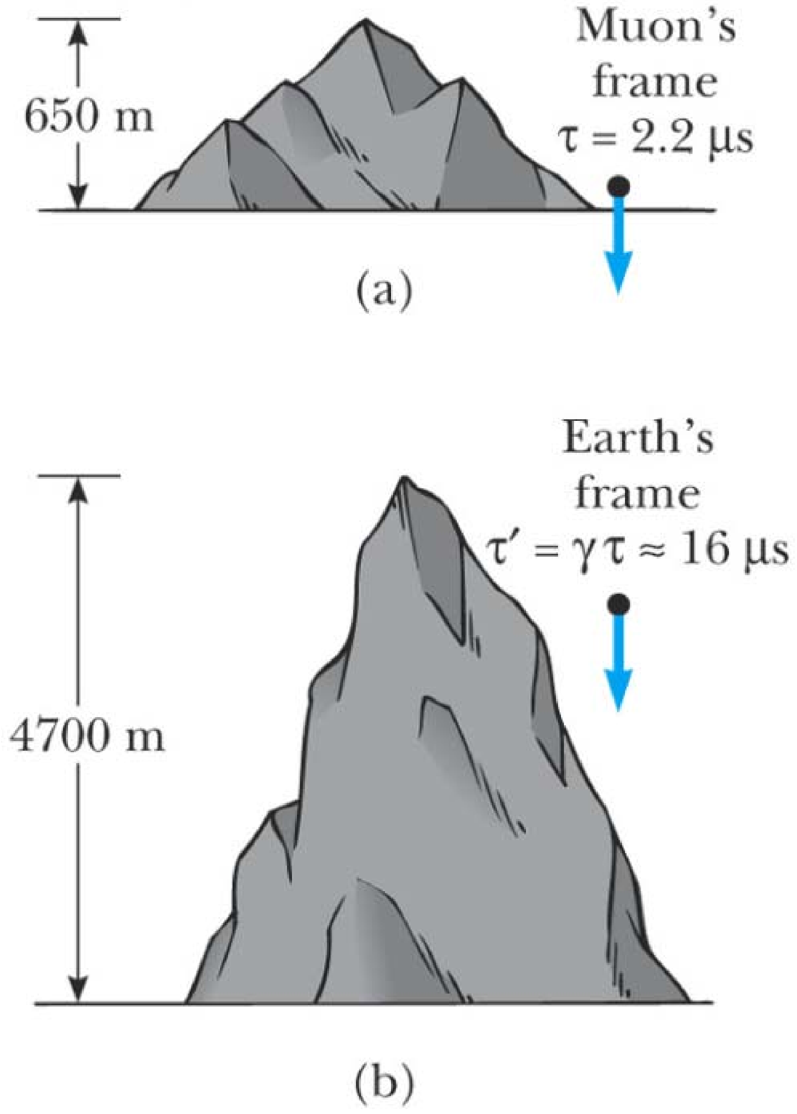
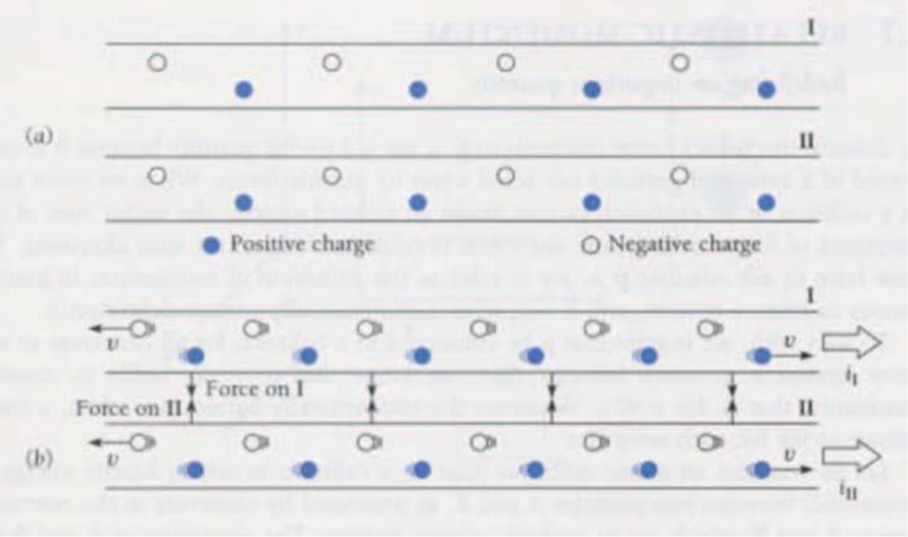
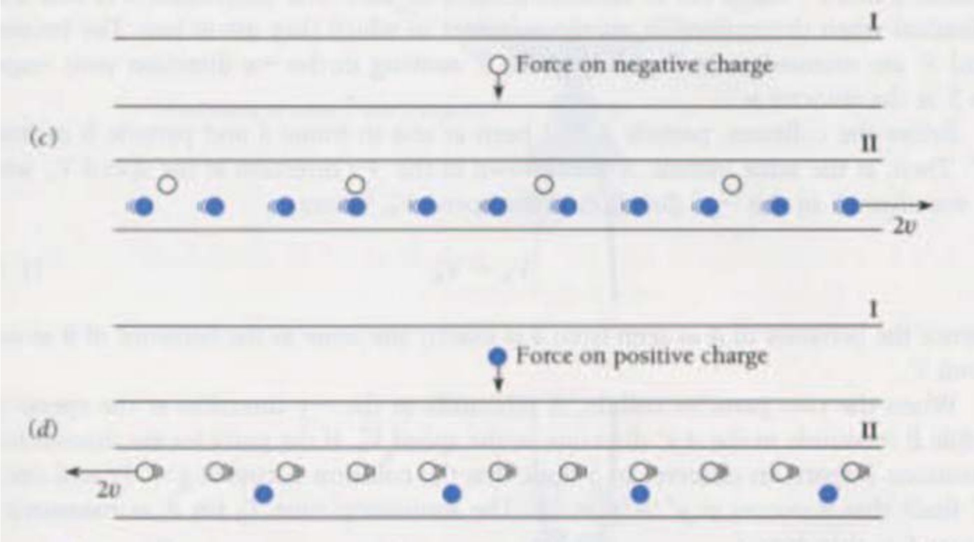


Fig. 1-11, p. 17


I
(a)
II
Positive charge
Negative charge
I
v
v
i_I
Force on I
Force on II
II
(b)
v
v
i_{II}


I
Force on negative charge
(c)
II
2v
I
Force on positive charge
(d)
II
2v

Galilean Transformation vs. Lorentz Transformation

Galilean Transformation

$$x' = x - vt$$

$$y' = y$$

$$z' = z$$

$$t' = t$$

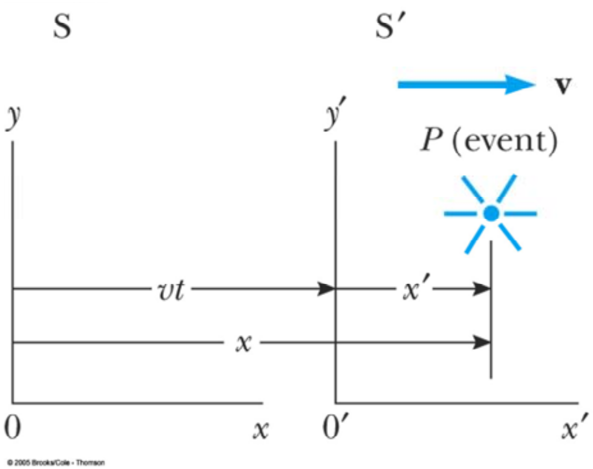


Fig. 1-2, p. 4

Lorentzian Transformation

$$x' = \gamma\left(x - vt\right)$$

$$y' = y$$

$$z' = z$$

$$t' = \gamma\left(t - \frac{v}{c^2}x\right)$$

where

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Lorentz Velocity Transformation

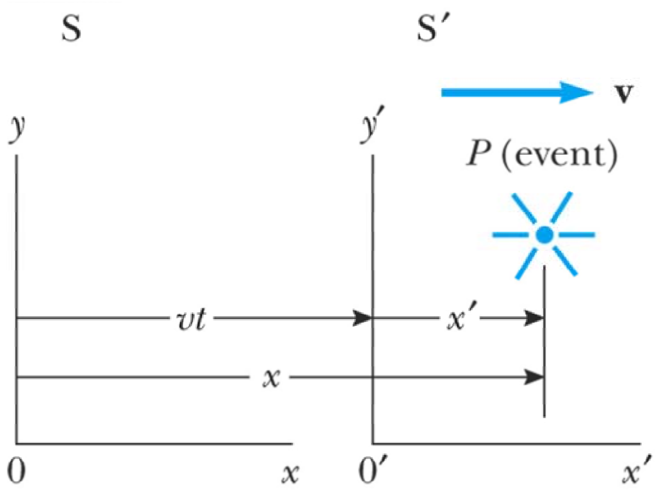


Fig. 1-2, p. 4

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

$$u'_y = \frac{u_y}{\gamma\left(1 - \frac{u_x v}{c^2}\right)}$$

$$u'_z = \frac{u_z}{\gamma\left(1 - \frac{u_x v}{c^2}\right)}$$

Einstein's Causality

Transmission of signal cannot be faster than the speed of light in vacuum.

The Time Machine – H. G. Wells, 1895

→ Impossible