РАЗДЕЛ III. ФИЗИКА

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Einstein unsuccessful attempt to derive Lorentz transform's formulae

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Abstract

It was shown that in his well-known work “On the Electrodynamics of Moving Bodies” Einstein in his attempt to derive the Lorentz transform's formulae by the way of a suggested mental experiment showed a physically mistaken interpretation of his experiment and some carelessness.

Keywords: principle of relativity, light velocity, inertial reference systems, space, coordinates, time.

Аннотация

Показано, что в своей широко известной работе «К электродинамике движущихся тел» Эйнштейн в попытке вывести формулы преобразования Лоренца путем предложенного им мысленного эксперимента проявил физически ошибочную трактовку этого эксперимента и недобросовестность.

Ключевые слова: принцип относительности, скорость света, инерциальные системы отсчета, пространство, координаты, время.

Introduction

In the second half of the ninetieth century many laboratories carried out intensive investigations about passing of light [1]. Michelson and Morley in their experiment [2] stated that the light velocity does not depend on the reference system velocity from which the measurements are carried out. Netherlands physicist Lorentz on the basis of this fact suggested [3] that moving through ether (which was accepted for the absolutely reference system) material bodies was accompanied by decreasing of their sizes in the direction of moving and derived formulae which tie space coordinates and time in inertial reference systems. French physicists Poincare called these formulae as the Lorentz's transforms [4]. Lorentz derived these formulae on the basis of analysis of electromagnetic processes which were considered from different inertial reference systems. Desiring to give demonstration of his own abilities Einstein made an attempt to derive these formulae with the help of a mental experiment, and in the final analysis he correctly wrote down them. But the paradox is caused by the next: 1) the interpretation of this mental experiment is mistaken and 2) even if to accept this interpretation without any analysis (on trust) as right it is impossible to derive the Lorentz's formulae with the right algebraical operations. This means that Einstein has known these formulae before but didn't refer to Lorentz's work and thus showed some carelessness.

Einstein's mental experiment

In §3 of stated above work [5] Einstein on the basis of principle of relativity and principle of the constancy of the velocity of light considers two inertial reference systems: the stationary system $K(x, y, z, t)$ and the system $k(\xi, \eta, \zeta, \tau)$ which is moving relatively to system K with velocity v to the direction of axis x so that axes ξ, η, ζ are parallel to axes x, y, z .

Quotation from work [5], page 7: “If we place $x' = x - vt$, it is clear that a point at rest in the system k must have a system of values x', y, z , independent of time... From the origin of system k let a ray be emitted at the time τ_0 along the X -axis to x' , and at the time τ_1 be reflected thence to the origin of the co-ordinates, arriving there at the time τ_2 ; we then must

have (Einstein did not numerate formulae but for convenience both following expression are numbered)

$$\frac{1}{2}(\tau_0 + \tau_2) = \tau_1, \quad (1)$$

or by inserting the arguments of the function and applying the principle of the constancy of the velocity of light in the stationary system:--

$$\begin{aligned} \frac{1}{2} \left[\tau_0(0, 0, 0, t) + \tau_2 \left(0, 0, 0, \left\{ t + \frac{x'}{V-v} + \frac{x'}{V+v} \right\} \right) \right] = \\ = \tau_1 \left(x', 0, 0, t + \frac{x'}{V-v} \right). \end{aligned} \quad (2)$$

In the written expression V is the velocity of light in vacuum. The considered mental experiment can be illustrated by the scheme which is showed in the picture where $K(x, y, z, t)$ is the stationary system. The device which consists of a radiator (point O) and a light reflector (point A) with a constant distance between them is moving with velocity v to the direction x of K -system. With this device it is connected the system of reference $k(\xi, \eta, \zeta, \tau)$.

Scheme of the mental experiment

On the assumption of the mentioned quotation it needs to consider x' as the distance between the radiator and the reflector measured in system K , and $x(t)$ as the coordinate of the reflector in this system because only then it will be right the relation written by Einstein: $x' = x - vt$. So that the question arises: why the ray is sent to x' but not to point A ?

On the assumption of relation (1) Einstein accepts that the ray, at measuring in system k , is passing the distance from radiator to reflector and back for equal periods, i.e. in this case the light velocity does not depend of a referent system moving. However, from relation (2) it is seen that at measuring in system K analogous periods do not equal, i.e. at moving of the ray to one side its velocity is equal $(V-v)$ and to opposite $-(V+v)$. But this contradicts the results of Michelson-Morley experiments which prove that the light velocity in vacuum does not depend on a reference system, but in the above relation the ray velocity at moving to one side is less than the light velocity in vacuum, but to another – greater. This is the mistaken interpretation by Einstein of his mental experiment.

Mathematical manipulations

Next Einstein performs passage to the limit in expression (2):

$$x' \rightarrow 0,$$

and obtains the equation that ties τ with x' and t :

$$\frac{\partial \tau}{\partial x'} + \frac{v}{V^2 - v^2} \frac{\partial \tau}{\partial t} = 0. \quad (3)$$

The solving of this equation is function

$$\tau = a \left(t - \frac{v}{V^2 - v^2} x' \right). \quad (4)$$

Further Einstein finds $a = 1$, so that later this constant will not be used. Making substitutions

$$\tau = \frac{\xi}{V} \text{ и } t = \frac{x'}{V-v},$$

he obtains

$$\xi = \frac{x'}{1 - \frac{v^2}{V^2}}. \quad (5)$$

Further he substitutes $x' = x - vt$ instead x' in expressions (4) and (5) and writes out next formulae, at that absolutely groundlessly places denominators of these expressions under square root and in that way transforms what he obtained into the Lorentz's formulae

$$\tau = \frac{t - \frac{vx}{V^2}}{\sqrt{1 - \frac{v^2}{V^2}}}, \quad (6)$$

$$\xi = \frac{x - vt}{\sqrt{1 - \frac{v^2}{V^2}}}. \quad (7)$$

But following to the algebraic rules by means of the pointed substitution it is impossible to obtain expressions (6) and (7) from (4) and (5). Really, let's do such substitution and then we obtain in the result:

$$\begin{aligned} \tau &= t - \frac{v}{V^2 - v^2} x' = t - \frac{v}{V^2 - v^2} (x - vt) = t - \frac{vx}{V^2 - v^2} + \frac{v^2 t}{V^2 - v^2} = \\ &= \frac{V^2 t - v^2 t - vx + v^2 t}{V^2 - v^2} = V^2 \left(\frac{t - \frac{vx}{V^2}}{V^2 - v^2} \right) = \frac{t - \frac{vx}{V^2}}{1 - \frac{v^2}{V^2}}, \\ \xi &= \frac{x'}{1 - \frac{v^2}{V^2}} = \frac{x - vt}{1 - \frac{v^2}{V^2}}. \end{aligned}$$

The fact of the matter is that Lorentz published his results including the transformations of coordinates and time from one inertial referent system to another in the year 1904, but Einstein only in 1905, so that he can place the denominators of expressions (6) and (7) under square root only knowing these formulae. In his work he tried to obtain them with the help of the mistaken mental experiment, but when this isn't obtained he juggled with the result because it is fishily to suspect him in implementation of any accidental algebraic mistake.

Conclusion

The stated facts compel to doubt in Einstein's scientific honesty, all the more that his article "On the Electrodynamics of Moving Bodies" does not have any references to other author's works. The matter appears so that the special theory of relativity is founded only by "great" Einstein himself. But the carried out analysis of his mental experiment arrives at an idea that he does not understand the background of this theory at that time.

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