# Determination of unidirectional speed of light in an inertial system

Karol Szostek
*Rzeszow University of Technology, Department of Fluid Mechanics and Aerodynamics, Rzeszow, Poland*
*kszostek@prz.edu.pl*

## Abstract:

In the article, was derived formulas for unidirectional speed of light in vacuum and material medium. Unidirectional speed of light is one of the important elements that distinguishes special theory of relativity [2] from ether theory [5]. The calculations are based on space-time transformation of ether theory [5].

**Keywords:** Speed of light, average speed, directional speed of light, special theory of relativity, special theory of ether.

## Introduction

It is a common belief in the contemporary physics that the Michelson-Morley [3] and Kennedy-Thorndike [1] experiments proved that the velocity of light is absolutely constant and that there is no universal reference system called the ether.

It turns out that the velocity of light in one direction (momentary) has never been accurately measured. Analysis of multiple experiments in this respect was made in book [7]. In all measurements of the velocity of light, only the average velocity of light traveling the path along the closed trajectory was measured [4].

In [4] - [6], an analysis of the Michelson-Morley and Kennedy-Thorndike experiments was carried out under different assumptions than they were done in Special Relativity. The considerations led to the explanation of these experiments based on the theory of ether, in which it is only required that in one reference system the speed of light to be constant. In [8] a kinematics model with any transverse shortening was presented, in which the assumptions of ether theory were generalized and the additional transverse shortening function $\psi(v)>0$ was introduced.

The method of derivation of unidirectional speed of light described in [4] ] was based on a complex relativistic geometry. Unidirectional velocity of light in a vacuum was determined without referring to relativistic geometry in [5].

## Unidirectional speed of light in a vacuum.

Based on the transformation from the $U$ system connected with ether $E$ to the inertial system $U'$ moving at velocity $v$, relative to the ether [4], [5], [6], speed transformations (1) can be determined:

$$V'_x = \frac{dx'}{dt'} = \frac{V_x - v}{1-(v/c)^2}, \quad V'_y = \frac{1}{\sqrt{1-(v/c)^2}} V_y, \quad V'_z = \frac{1}{\sqrt{1-(v/c)^2}} V_z, \ (1)$$

as in [4][5].

The flow of the light beam in the universal reference system $U$-URF at an angle $\alpha$ is shown in Fig. 1. a), the flow of the same light stream in the inertial system $U'$ at angle $\alpha'$ is shown in Fig. 1. b). The $x$, $y$, $z$ coordinate system has been set in relation to the direction of velocity $v$ of the inertial system $U'$ and direction of light flow as so that the third component of the speed of light is equal zero $c_z$=$c_z'$=0.

a) b)

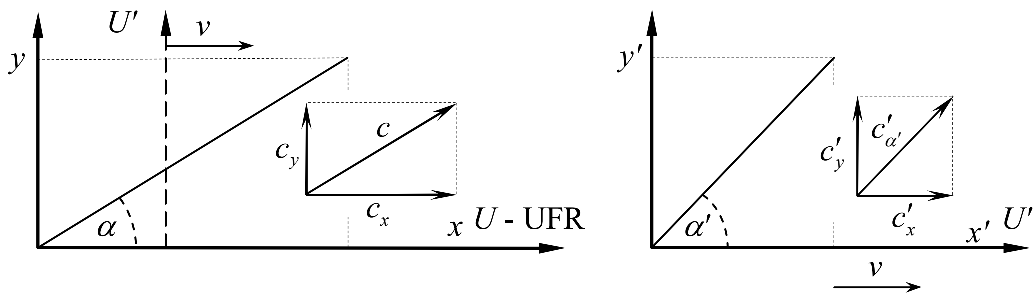


Fig. 1. The flow of light beam at angle a) in the universal reference system URF, at an angle $\alpha$, and b) in the inertial system $U'$, at angle $\alpha'$,

To determine the dependence on the speed of light in a vacuum at any angle, was solved the system of five equations (2). The first and second equations were obtained on the basis of Pythagorean theorem applied to light velocities components in both systems, the third was obtained from definition of the cosine angle of light beam in the inertial system $U'$, the fourth and fifth equations were determined from the velocity transformation (1) applied to the components of the speed of light beam Fig. 1.,

$$\begin{cases} c'^2_{\alpha'} = c'^2_x + c'^2_y, \qquad c^2 = c_x^2 + c_y^2, \\ \cos\alpha' = \dfrac{c'_x}{c'_{\alpha'}}, \\ c'_x = \dfrac{c_x - v}{1-(v/c)^2}, \quad c'_y = \dfrac{c_y}{\sqrt{1-(v/c)^2}}. \end{cases} \qquad (2)$$

In the system of equations (2) are given: $v$, $c$, $\alpha'$, and unknown are: $c_x$, $c_y$, $c_{x'}$ $c_{y'}$ and $c'_{\alpha'}$. The system of equations was solved due to $c'_{\alpha'}$. From the fourth equation $c_x$ was calculated, and substituted into the second equation, from the second equation, $c_y$ was calculated and substituted into the fifth equation, $c'_y$ from the fifth was inserted into the first equation, hence (3) was obtained,

$$c'^2_{\alpha'} = c'^2_x + \frac{c^2 - \{c'_x[1-(v/c)^2]+v\}^2}{1-(v/c)^2}. \quad (3)$$

Equation (3) was converted as shown in (4) - (5),

$$c'^2_{\alpha'}(c^2-v^2) = c'^2_x(c^2-v^2) + c^2(c^2-v^2) - c'^2_x\frac{(c^2-v^2)^2}{c^2} - 2c'_x(c^2-v^2)v, \quad (4)$$

$$c'_{\alpha'} = \frac{c^2}{c + v\dfrac{c'_x}{c'_{\alpha'}}}. \quad (5)$$

After substituting the dependence on cos $\alpha'$ from the third equation of the system (2) into equation (5), formula (6) was obtained for the unidirectional speed of light in vacuum,

$$c'_{\alpha'} = \frac{c^2}{c + v\cos\alpha'}. \quad (6)$$

## Unidirectional speed of light in a material medium.

On the Figure Fig. 2. was shown the bidirectional flow of light in the inertial system $U'$ on the path $L$. In one direction the light flows in the material medium at the speed of $c'_{s\alpha'}$ and in the other in vacuum at the speed of $c'_{\beta'}$. Fig. 2. a) shows the flow of the light beam in the medium at right angles $\alpha'=\pm\pi/2$, $\beta'=-\pi/2$, Fig. 2. b) at any angle $\alpha'$, $\beta'=180-\alpha'$.

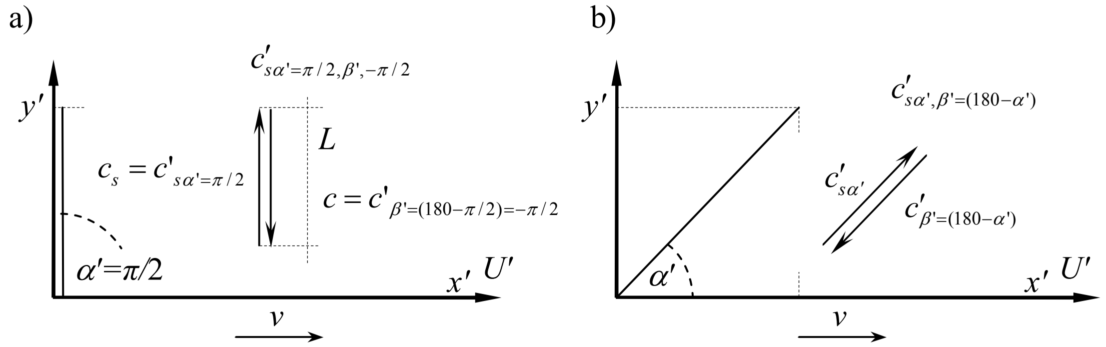


Fig. 2. The flow of light in the inertial system $U'$ moving in URF at speed $v$, firstly light flow in a material medium and then in vacuum
a) light flow at a right angle $\alpha'=\pm\pi/2$ in the system $U'$,
b) at any angle $\alpha'$.

**assumptions:**

I- It was assumed that in an experiment in which light flows, in one direction in a material medium at the speed of $c'_{s\alpha'}$ 'and in the other in a vacuum at the speed of $c'_{\beta'=(180-\alpha')}$, the average speed of light $c'_{s\alpha',\beta'=(180-\alpha')}$, on the path $L$ is independent of the direction i.e. angle $\alpha'$, and velocity $v$ of the inertial system $U'$, hence we can write (7),

$$c'_{s\alpha'=\pi/2,\beta'=-\pi/2} = c'_{s\alpha',\beta'=(180-\alpha')} = const. \quad (7)$$

II It was assumed that the two-way average light velocity in both direction in the material medium $c'_{s\alpha',s\beta'=(180-\alpha')}$ is constant and equal to the average light velocity $c_s$, this velocity is independent of the direction i.e. angle $\alpha'$, and velocity $v$ of the system inertial $U'$, hence you can write (8),

$$c'_{s\alpha'=\pi/2,s\beta'=-\pi/2} = c'_{s\alpha',s\beta'=(180-\alpha')} = c_s = const \quad (8)$$

Based on the markings in Fig. 2. b), the average speed of light $c'_{s\alpha',\beta'=(180-\alpha')}$ on the path $L$ can be written as in (9),

$$c'_{s\alpha',\beta'=(180-\alpha')} = \frac{2L}{\dfrac{L}{c'_{s\alpha'}} + \dfrac{L}{c'_{\beta'=(180-\alpha')}}}, = 2\frac{c'_{s\alpha'}c'_{\beta'=(180-\alpha')}}{c'_{s\alpha'} + c'_{\beta'=(180-\alpha')}}. \quad (9)$$

If the light runs at a right angle $\alpha'=\pm\pi/2$ to the speed $v$ of the inertial system $U'$ Fig. 2. a), then in both directions the speed of light has the same value equal to the average value in a given medium. This property results from the fact that the directions back and forth perpendicular to the speed of the inertial system $v$ are indistinguishable, hence from that from assumption II the equations (10) can be written,

$$\begin{aligned} c'_{s\alpha'=\pi/2,s\beta'=-\pi/2} &= c'_{s\alpha'=\pi/2} = c'_{s\beta'=-\pi/2} = c_s, \\ c'_{\alpha'=\pi/2,\beta'=-\pi/2} &= c'_{\alpha'=\pi/2} = c'_{\beta'=-\pi/2} = c. \end{aligned} \quad (10)$$

From equations (10) the average speed of light was determined for the angle $\alpha'=\pi/2$, $\beta'=\pi/2$, flowing in one direction in a medium and in other in vacuum, equation (11),

$$c'_{s\alpha'=\pi/2,\beta'=-\pi/2} = 2\frac{L}{\dfrac{L}{c_s} + \dfrac{L}{c}}, = 2\frac{c_s c}{c_s + c}. \quad (11)$$

Substituting equations (9) and (11) into equation (7), second equation of the system (12) was obtained, which links average values of light velocity in vacuum and medium with unidirectional values. The directional velocity in a material medium can be determined by solving the system of equations (12).

$$\begin{cases} c'_{\beta'} = \dfrac{c^2}{c + v\cos\beta'} \\ \dfrac{c'_{s\alpha'}c'_{\beta'}}{c'_{s\alpha'} + c'_{\beta'}} = \dfrac{c_s c}{c_s + c}. \end{cases} \quad (12)$$

From the first equation of the system (12) $v\cos\beta'$ (13) was determined,

$$v\cos\beta' = \frac{c^2 - c'_{\beta'}c}{c'_{\beta'}}, \quad (13)$$

The second equation of the system (12) was transformed to equations (14),

$$c'_{s\alpha'} = \frac{1}{\frac{(c_s + c)}{c_s c} - \frac{1}{c'_{\beta'}}}. \quad (14)$$

The numerator and denominator of the right side of equation (14) were multiplied by $c_s c^2$, hence was obtained (15),

$$c'_{s\alpha'} = \frac{c^2 c_s}{c^2 - c_s \frac{c^2 - c'_{\beta'}c}{c'_{\beta'}}}. \quad (15)$$

After substituting $v\cos\beta'$ from equation (13) to (15) and taking into account that $\beta'$=180-$\alpha'$ the formula (16) for unidirectional velocity of light in the material medium was obtained,

$$c'_{s\alpha'} = \frac{c^2 c_s}{c^2 - c_s v\cos\beta'} = \frac{c^2 c_s}{c^2 + c_s v\cos\alpha'}. \quad (16)$$

## Conclusions:

The article presents a new method for deriving the unidirectional speed of light in a material medium. The velocity was determined on the basis of the transformation of space-time of ether theory [5], and additional assumptions that was made.

By determining the directional speed of light, consistent with the results of the Michelson a-Morley experiments, it was shown that despite the fact that this experiment and similar ones did not give positive results, i.e. no changes in the interference image were detected, the rejection of the existence of ether in which light flows was unfounded based only on those experiments.

## References:

[1] Kennedy Roy J., Thorndike Edward M., *Experimental Establishment of the Relativity of Time*, Physical Review, 42 (3), 400-418, 1932.

[2] Mansouri Reza, Sexl Roman U., *A Test Theory of Special Relativity*: *I. Simultaneity and Clock Synchronization*, General Relativity and Gravitation, Vol. 8, No. 7, 497-513, 1977.

[3] Michelson Albert A., Morley Edward W., *On the relative motion of the earth and the luminiferous ether*, American Journal of Science, 34, 333-345, 1887.

[4] Szostek Karol, Szostek Roman, *The derivation of the general form of kinematics with the universal reference system Results in Physics, Vol. 8, 2018, 429-437* (https://doi.org/10.1016/j.rinp.2017.12.053)*, ISSN: 2211-3797*

[5] Szostek Karol, Szostek Roman, *Special Theory of Ether* (w języku angielskim), Publishing house AMELIA, Rzeszów, Poland, 2015, (www.ste.com.pl), ISBN 978-83-63359-81-2.

[6] Szostek Roman, Szostek Karol, *Kinematics in Special Theory of Ether* (w języku angielskim: *Kinematyka w Szczególnej Teorii Eteru*), Moscow University Physics Bulletin, Vol. 73, № 4, **2018**, 413-421, ISSN: 0027-1349, https://link.springer.com/article/10.3103/S0027134918040136

[7] Yuan Zhong Zhang, *Special Relativity and Its Experimental Foundation*, Singapore, World Scientific Publishing, 1997.

[8] Szostek Roman, *Derivation method of numerous dynamics in the Special Theory of Relativity* (w języku angielskim), Open Physics, Vol. 17, 2019, 153-166, ISSN: 2391-5471, https://doi.org/10.1515/phys-2019-0016.