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The Second-Order Effects in the "Rotating Disk" Experiment

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Abstract

We find the second-order in v/c effects in the four different modifications of the "rotating disk" experiment whose first-order effects have been analyzed and the experimental results obtained by us reported in another paper. The differences between our absolute space-time theory and the Newtonian ether theory are within effects of second order in v/c. We propose experiments for the measurement of the second-order effects on the "rotating disk" that can be considered as *experimenta crucis* between both theories.

1. *Introduction*

We have dedicated earlier papers to the analysis of the first-order in v/c effects in the "rotating disk" experiment (Marinov, 1975a, 1976a, 1976b). In Marinov (1976a) we give the account of the disrupted "rotating disk" experiment and in Marinov (1976b) of the Harress–Marinov and Harress–Fizeau experiments, performed recently by us. All these experiments, as well as the "coupled-mirrors" experiment (Marinov, 1974b, 1976c), with whose help we have measured for the first time in history the Earth's absolute velocity, show that the velocity of light is direction dependent in any frame moving with respect to absolute space. Within effects of first order in v/c this dependence is the same as that predicted by the Newtonian ether theory.

However, our absolute space-time theory (Marinov, 1975b) leads to effects of second order in v/c that differ from those predicted by the ether theory. In this paper we shall show which are the second-order effects in the "rotating disk" experiment according to our conceptions. Before tackling this problem we shall find by the help of our "hitch-hiker" model (Marinov, 1974a) the velocity of light in a medium that rests in absolute space if this velocity is measured in a frame (i.e., by an observer) moving with respect to absolute space.

2. *Velocity of Light in a Medium at Rest Measured by a Moving Observer*

In Marinov (1974a) we have found the velocity of light in a medium that moves at velocity v in absolute space measured by an observer who is at rest. Now we shall find the velocity of light in a medium that rests in absolute space measured by an obşerver who moves at velocity v. The theory of relativity cannot make such a distinction because for this theory only the relative velocity between the medium and the observer is of importance. Our absolute space-time theory can pose this problem and resolve it, and, as we have experimentally established (Marinov, 1976b), experience has splendidly verified our predictions.

Thus let there be (see Figure 1) a medium with refractive index n that is at rest in absolute space and in which light propagates along a direction that makes an angle θ with the x axis of a frame K attached to absolute space. Let another frame K' move at velocity v along the positive direction of the x axis of K and assume that the x axes of both frames are collinear and the y axes parallel.

We choose as a time unit the time between two successive absorptions of a photon on the molecules of the medium. At such a choice of the time unit a photon propagating along the direction AF in the rest frame K is "hitched" $(1 - 1/n)$th part of the time unit onto a molecule that rests at point A and $(1/n)$th part of the time unit moves along the line AF until it is "hitched" again onto another molecule, which rests at point F (see Marinov, 1974a).

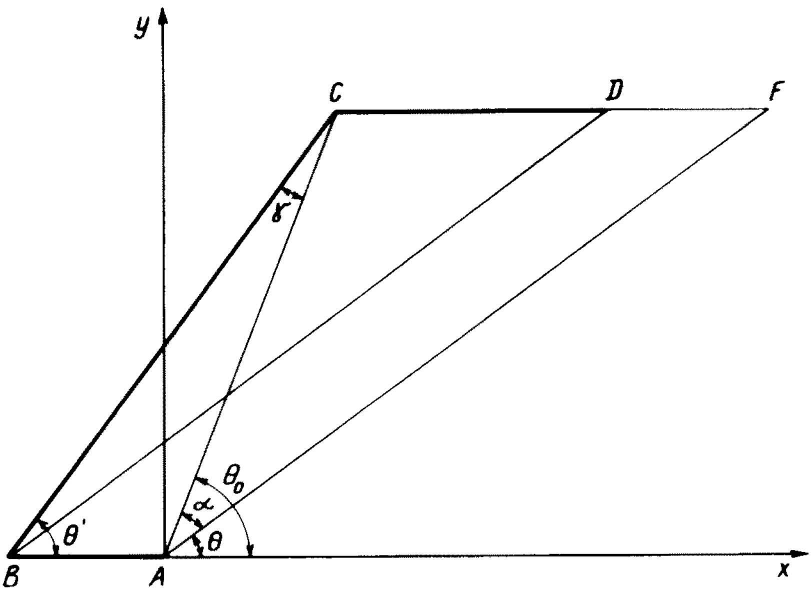

Fig. 1. The paths of a photon proceeding in a medium that rests in absolute space with respect to the rest and moving frames.

In the moving frame K' we shall have the following picture: During the time in which the photon is "hitched" it will cover the distance AB with velocity v and during the time in which the photon propagates with velocity c in absolute space it will cover distance BC in K' (at an angle θ' to the x' axis) with a velocity (measured on a clock that rests in K'!) (Marinov, 1976c)

$$c_0' = \frac{c}{1 + (v/c)\cos\theta'} \tag{2.1}$$

since during the time in which the photon has covered the broken line ABC in frame K' the molecule that rests at point F in absolute space has covered distance FC in K' with velocity v. We call (Marinov, 1976c) c_0' the proper relative light velocity. The mean proper relative light velocity in frame K' (i.e., the average light velocity measured in K' by the help of a clock that rests there) will make an angle θ_0 with the x' axis and have magnitude

$$c_{0m}' = AC = (AB^2 + BC^2 - 2AB \cdot BC \cos\theta')^{1/2} \tag{2.2}$$

since the time between two successive absorptions of the photon is taken equal to unity.

Substituting into (2.2)

$$AB = v(1 - 1/n), \qquad BC = \frac{c}{1 + (v/c)\cos\theta'}\,\frac{1}{n} \tag{2.3}$$

and working within an accuracy of second order in v/c, we obtain

$$c_{0m}' = \frac{c}{n} - v\cos\theta' + \frac{v^2}{cn}\cos^2\theta' + \frac{1}{2}\frac{v^2}{c}n\left(1 - \frac{1}{n}\right)^2\sin^2\theta' \tag{2.4}$$

The angle that the observer should measure between the direction of propagation of light and the x' axis in frame K' is θ_0. Thus, substituting into (2.4)

$$\theta' = \theta_0 - \gamma \tag{2.5}$$

where γ is a small angle and, as we shall see further, within the necessary accuracy we can take

$$\sin\gamma = \frac{AB\sin\theta'}{AC} \cong \frac{v}{c}(n-1)\sin\theta' \cong \frac{v}{c}(n-1)\sin\theta_0 \tag{2.6}$$

we obtain

$$c_{0m}' = \frac{c}{n} - v\cos\theta_0 + \frac{v^2}{cn}\cos^2\theta_0 - \frac{1}{2}\frac{v^2}{c}n\left(1 - \frac{1}{n^2}\right)\sin^2\theta_0 \tag{2.7}$$

The angle between the x axis and the direction of propagation of light whicl should be measured in frame K is θ. Thus, substituting into (2.7)

$$\theta_0 = \theta + \alpha \tag{2.8}$$

where α is a small angle and, as we shall see further, within the necessary accuracy we can take

$$\sin \alpha = \frac{CF \sin \theta}{AC} \cong \frac{v}{c} n \sin \theta \tag{2.9}$$

we obtain

$$c'_{0m} = \frac{c}{n} - v \cos \theta + \frac{v^2}{cn} \cos^2\theta + \frac{1}{2}\frac{v^2}{c} n \left(1 + \frac{1}{n^2}\right) \sin^2\theta \tag{2.10}$$

If $n = 1$, it will be $c'_{0m} = c'_0$, so that formula (2.7) reduces to the following one (for $n = 1$ it is $\theta_0 = \theta'$):

$$c'_0 = c - v \cos \theta' + (v^2/c) \cos^2\theta' \tag{2.11}$$

and formula (2.10) reduces to the following one:

$$c'_0 = c - v \cos \theta + v^2/c \tag{2.12}$$

which coincide within an accuracy of second order in v/c, respectively, with the first and second formulas for the proper relative light velocity in a frame moving at velocity v in absolute space (Marinov, 1976c)

$$c'_0 = \frac{c}{1 + (v/c) \cos \theta'} = c\, \frac{1 - (v/c) \cos \theta}{1 - v^2/c^2} \tag{2.13}$$

For $\theta = \theta_0 = 0$, formulas (2.7) and (2.10) give

$$c'_{0m} = \frac{c}{n} - v + \frac{v^2}{cn} \tag{2.14}$$

For $\theta = \pi/2$, $\theta_0 = \pi/2 + (v/c) n$, formulas (2.7) and (2.10) give

$$c'_{0m} = \frac{c}{n} + \frac{1}{2}\frac{v^2}{c} n \left(1 + \frac{1}{n^2}\right) \tag{2.15}$$

We recall (Marinov, 1976c) that c'_0 is the proper relative light velocity, i.e., c'_0 is the light velocity in the moving frame measured by the help of a clock which is attached to the moving frame. The absolute relative light velocity, called for short relative light velocity, is the same quantity, but measured by the help of a clock that is attached to absolute space, and it is equal to

$$c' = c'_0 (1 - v^2/c^2)^{1/2} \tag{2.16}$$

Let us find now the velocity of light in a medium moving with respect to absolute space and measured in a frame attached to the medium.

Since in such a case $(1 - 1/n)$th part of the time unit the photon is "hitched" and does not move with respect to the moving frame K', then the "effective" velocity of the frame with respect to the trajectory of the "free" photon will be $(1/n)v$. Thus, according to formula (2.13), the proper velocity of the "free" photon with respect to K' will be

$$c_0' = \frac{c}{1 + (v/cn)\cos\theta'} = c\,\frac{1 - (v/cn)\cos\theta}{1 - (v^2/c^2n^2)} \tag{2.17}$$

With this velocity the photon moves only $(1/n)$th part of the time unit, so that the mean proper velocity with respect to K' will be

$$c_{0m}' = \frac{1}{n}c_0' = \frac{c}{n}\,\frac{1}{1 + (v/cn)\cos\theta'} = \frac{c}{n}\,\frac{1 - (v/cn)\cos\theta}{1 - (v^2/c^2n^2)} \tag{2.18}$$

where θ' and θ are the angles between the direction of light propagation and the x axes, respectively, in the moving and rest frames.

This result can be obtained by the help of Figure 1 in Marinov (1974a). Let us note, however, that if we should use the notations given in Marinov (1974a), we should obtain the following expression for the mean velocity with respect to K':

$$c_m' = \frac{BC}{t_m} = \frac{c}{n}\,\frac{1}{1 + (v/cn)\cos\theta' + \frac{1}{2}(v^2/c^2n)\sin^2\theta'} \tag{2.19}$$

This formula gives the mean light velocity with respect to the moving frame K' measured in absolute time, i.e., the quantity [see (2.16)]

$$c_m' = c_{0m}'\,(1 - v^2/c^2)^{1/2} \tag{2.20}$$

The difference in the second-order terms in the formulas (2.19) and (2.20), substituting (2.18) into the latter, appears as a result of the fact that in obtaining (2.19) we have used only traditional Newtonian conceptions, while when obtaining (2.18) we have used formula (2.13) for the light velocity in a moving frame given by our absolute space-time theory, which is the true one. Thus only formulas (2.18) and (2.20) correspond to physical reality, while formula (2.19) corresponds to physical reality within the terms of first order in v/c.

3. *The Second-Order Effects in the Harress–Marinov, -Sagnac, -Fizeau, and -Pogany Experiments*

The measurement of the second-order effects in the "rotating disk" experiment is a technologically difficult problem, and in our laboratory we cannot cope with it. For this reason we shall propose such experiments without entering into the details of an eventual practical realization.

The setup for a measurement of the second-order effects in the "rotating disk" experiment is shown in Figure 2. A medium with refractive index n made

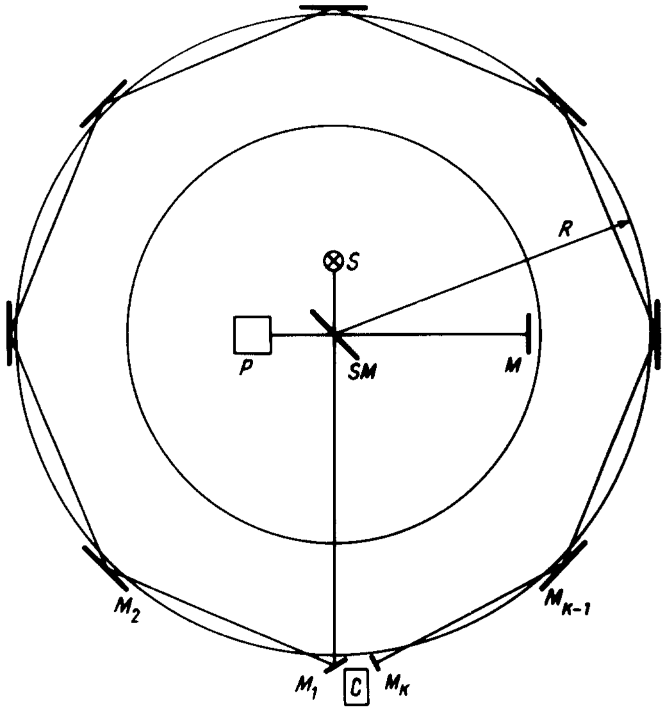

Fig. 2. The setup for the measurement of the second-order effects on the rotating disk.

in the form of a cylindrical ring (Marinov, 1976b) with outer radius R can rotate with the mirrors $M_1, M_2, \ldots, M_{k-1}, M_k$ or without them, or only the mirrors can rotate and the medium remain at rest. In the latter case medium with refractive index $n = 1$, i.e., vacuum (air) can be also taken. So there are four different possible combinations, as follows (see Marinov, 1976b):

1. The Harress–Marinov experiment, in which the medium is at rest and the mirrors rotate.
2. The Harress–Sagnac experiment, in which the medium is vacuum and the mirrors rotate.
3. The Harress–Fizeau experiment, in which the medium rotates and the mirrors are at rest.
4. The Harress–Pogany experiment, in which the medium rotates together with the mirrors.

Let us note that it will be very difficult to measure the second-order effects in the Harress–Marinov and Harress–Fizeau experiments, because there is a relative motion between mirrors and medium, so the performance of the Harress–Sagnac and Harress–Pogany experiments should be easier.

In Figure 2 S is a light source emitting coherent light, which is rigidly connected with the mirrors because the effect to be measured is too small and the use of a shutter that is governed by the rotating disk (Marinov, 1976b) would probably discredit the experiment. P is a photoresistor illuminated by interference light. It is put in one arm of a Wheatstone bridge, in whose other arm there is a variable resistor. We should assume that $M_1, M_2, \ldots, M_{k-1}, M_k$ are placed close enough to the rim of the medium's disk. Thus we can assume that the photons fly along the circumference of a circle and cover a path $d = 2\pi R$

Let us suppose first that the disk is at rest. Light emitted by the source S is split by the semitransparent mirror SM into first and second beams. The first beam reflects on the mirror M and after refraction on SM illuminates P. The second beam reflects successively on $M_1, \ldots, M_k$ clockwise and on $M_k, \ldots, M_1$ counterclockwise and after reflection on SM illuminates P.

If now we set the disk in rotation, then the first beam should not change the time in which it will cover its path, because all the time it moves along the radius of the rotating disk, while the second beam should change its time with Δt. Now we shall calculate this time difference for the four different types of the "rotating disk" experiment.

Let us consider first the Harress-Marinov experiment. Using formulas (2.14) and (2.20) we find that the difference in the absolute times which the second beam should spend to cover its path in the cases of rest and rotation of the mirrors will be

$$\Delta t_{H\text{-}M} = \frac{d}{c_m'^+} + \frac{d}{c_m'^-} - \frac{2d}{c_m} = \frac{dv^2}{c^3} n(2n^2 - 1) \tag{3.1}$$

For $n = 1$, i.e., for the second-order effect in the Harress-Sagnac experiment we obtain

$$\Delta t_{H\text{-}S} = \frac{dv^2}{c^3} \tag{3.2}$$

It can easily be seen that for the first-order effects in the Harress-Marinov and Harress-Sagnac experiments we shall obtain the same formulas as in Marinov (1976b), where the calculation was made in a somewhat different way.

Let us now consider the Harress-Fizeau experiment. Using formula (17) from (Marinov, 1974a), we find that the difference in the absolute times which the second beam should spend to cover its path in the cases of rest and rotation of the medium will be

$$\Delta t_{H-P} = \frac{d}{c_m^+} + \frac{d}{c_m^-} - \frac{2d}{c_m} = \frac{2dv^2}{c^3}\, n(n^2 - 1) \tag{3.3}$$

And finally let us consider the Harress-Pogany experiment. Using formula (2.18) for $\theta' = \theta = 0$, and formula (2.20), we obtain

$$\Delta t_{H-P} = \frac{d}{c_m'^+} + \frac{d}{c_m'^-} - \frac{2d}{c_m} = \frac{dv^2}{c^3} n \tag{3.4}$$

From this formula for $n = 1$ we obtain again the second-order effect (3.2) in the Harress-Sagnac experiment.

4. *The Second-Order Effects in the "Rotating Disk" Experiment and the Absolute Time Dilation*

The second-order effects in the "rotating disk" experiment are very important for the understanding and for establishment of our absolute time dilation conception. Let us show this.

As is well known (see, for example, Marinov, 1975b), a light clock represents two mirrors placed in front of each other between which a light pulse goes "there and back." Instead of two mirrors we can have an arbitrary number. Of importance is only that a light pulse that leaves a given point, returns again to it, and repeats this cycle uninterruptedly. Thus our mirrors $M_1, M_2, \ldots, M_k, \ldots, M_2, M_1$ represent also a light clock.

Let the time that a light pulse spends covering the path d "there and back" be T when the mirrors are at rest. Thus $T = 2d/c$ is the rest period of our clock. When the mirrors are set in rotational motion with velocity $v = \Omega R$, where Ω is the angular velocity, the period of the light clock measured in absolute time, i.e., by the help of a clock that rests in absolute space, will be [see formulas (2.13) and (2.16)]

$$T_0 = \frac{d}{c'^+} + \frac{d}{c'^-} = \frac{2d}{c(1 - v^2/c^2)^{1/2}} = \frac{T}{(1 - v^2/c^2)^{1/2}} \tag{4.1}$$

while the same period measured in proper time, i.e., by the help of a clock that is attached to the rim of the moving disk, will be

$$T_{00} = \frac{d}{c_0'^+} + \frac{d}{c_0'^-} = \frac{2d}{c} = T \tag{4.2}$$

Thus the period of our light clock rotating with velocity v in absolute space, as the period of any proceeding as a whole with velocity v light clock (Marinov, 1975b), becomes longer, according to formula (4.1). We have called this effect the absolute kinematic time dilation. Let us note that to the absolute dynamic time dilation, i.e., to the dilation of the periods of light clocks placed near local concentrations of matter, we have dedicated our paper (Marinov, 1976d). Further, in the present paper we shall consider only the kinematic time dilation.

According to the tenth (high-velocity) axiom of our absolute space-time theory (Marinov, 1976c, 1976d), the time unit for any observer is determined by the period of a light clock that has the same "arm" for all observers. When the "arm" is $d = 150{,}000$ km, then this time unit is called a second. If the observer is at rest in absolute space, his second is called absolute. If the observer moves with certain velocity in absolute space, his second is called proper. Obviously, any proper second is larger then the absolute second and the relation is given by formula (4.1), where T_0 is the duration of the proper second in absolute time and T is the duration of the absolute second in absolute time. However this change in the duration of the period of a light clock, when being put in motion, can be established only comparing its period with a periodical process of a system that is at rest in absolute space (in general, which does not change its velocity when the light clock under investigation changes its velocity). If we should compare the period of the light clock considered with the periodical process of a system that all the time moves with the same velocity as the light clock, then no change can be registered, as follows from formula (4.2). This is due to the fact that the rhythm of *any* periodical process decreases according to formula (4.1) if the corresponding system is set in motion with velocity v.

All these assertions of our absolute space-time theory can be verified experimentally if one measures the second-order effect in the Harress–Sagnac experiment.

The second-order effect in the Harress–Sagnac experiment was treated by Burcev (1974), who has proposed also an experiment for its measurement. Burcev's proposal consists in the following: Let there by a number (≥ 3) of artificial satellites moving along the same circular trajectory round the Earth with a certain velocity v. If a radar pulse is emitted from the one of the satellites, then by means of reflections in the other satellites this radar pulse can be again received after having covered a closed path round the Earth, and the time of delay can be measured with high precision. If we suppose that the satellites are placed close enough to each other, then the trajectory of the radar wave can be assumed as circular and the gravitational potentials at all points crossed by the wave as equal. Thus any reference made by Burcev to Shapiro's experiment (Shapiro, 1968) [where the cover times of radar signals passing the *same* distance in regions with *different* gravitational potentials are measured—see Marinov (1976d)] is out of place, and we can treat Burcev's proposal by the help of our Figure 2, assuming that clock C (an atomic clock) is attached to the mirrors M_1 and M_k, so that the time in which a light pulse covers the path from M_1 to M_k, or from M_k to M_1, can be measured.

According to the Einstein theory of general relativity (Burcev, 1974; Landau and Lifshitz, 1955; Tonnelat, 1964) this time, respectively, for the "direct" (+) and "opposite" (−) pulse is

$$t_E^{\pm} = t\,\frac{1 \pm v/c}{(1 - v^2/c^2)^{1/2}} \tag{4.3}$$

where $t = d/c = 2\pi R/c$ is the time registered on the same clock if the disk is at rest.

According to the traditional Newtonian ether theory this time is

$$t_N^{\pm} = \frac{t}{1 \mp v/c} \tag{4.4}$$

According to our absolute space-time theory this time is [see formula (2.13)]

$$t_M^{\pm} = t_0^{\pm} = \frac{d}{c_0'^{\pm}} = t\left(1 \pm \frac{v}{c}\right) \tag{4.5}$$

If this time should be measured on a clock that rests in absolute space, it will be

$$t^{\pm} = \frac{d}{c'^{\pm}} = t\,\frac{1 \pm v/c}{(1 - v^2/c^2)^{1/2}} \tag{4.6}$$

When we have to measure the absolute time interval $t^{\pm}$ by the help of a clock that rests in absolute space, the problem arises about the time synchronization of spatially separated clocks. This problem is solved by us (theoretically and *practically*) by the help of a rotating rigid shaft. However, in the "rotating disk" experiment the problem about the time synchronization of spatially separated clocks can be eliminated if we choose an appropriate rotational velocity v, so that the light pulse, emitted by M_1 when it passes near the clock C, which is at rest, will arrive at M_k when M_k passes (after one or more revolutions) near C.

Let us note that Burcev (1974) wrongly writes formula (4.5) as corresponding to the Newtonian ether theory. In a letter to the author of 18 September 1974 he agreed that the true formula that must be written when proceeding from the traditional Newtonian theory is (4.4).

We have to add here that according to the majority of the relativists the "rotating disk" experiment can be treated only with the help of the mathematical apparatus of general relativity. However certain relativists (see, for example, Laue, 1955) assert that this can be done also by the apparatus of special relativity and perform suitable calculations making use of the Lorentz transformation.

Let us see what results the special relativity way leads to. Let us attach a moving frame K' to the rotating disk and a rest frame K to absolute space. Obviously, K' is not an inertial frame because at any moment its velocity changes its direction. However, the absolute value of the velocity remains constant and this makes it possible to use the Lorentz transformation formulas. For the initial event (sending of a light pulse from M_1) let us take $x_1' = 0$, $t_1' = 0$ and for the final event (arriving of the signal at M_k) $x_2' = d$, $t_2' = d/c$. Substituting these values into the Lorentz transformation formulas for time (see, for example, Marinov, 1975b) and subtracting the first formula thus obtained from the second, we obtain the result (4.6). Now this time is measured on a clock that is at rest. The time measured on a clock that is attached to the moving disk must be equal to $t' = d/c$, *both* for the "direct" and for the "opposite" pulses.

In Figure 3 we give the graphs of the relations t^{+}/t versus v/c drawn according to formulas (4.3)–(4.5). Thus an experiment such as the one proposed by Burcev can choose between these three rival theories. However, since the relativity theory was knocked out by our "coupled-mirrors" experiment (Marinov, 1976c), as well as by the disrupted "rotating disk"

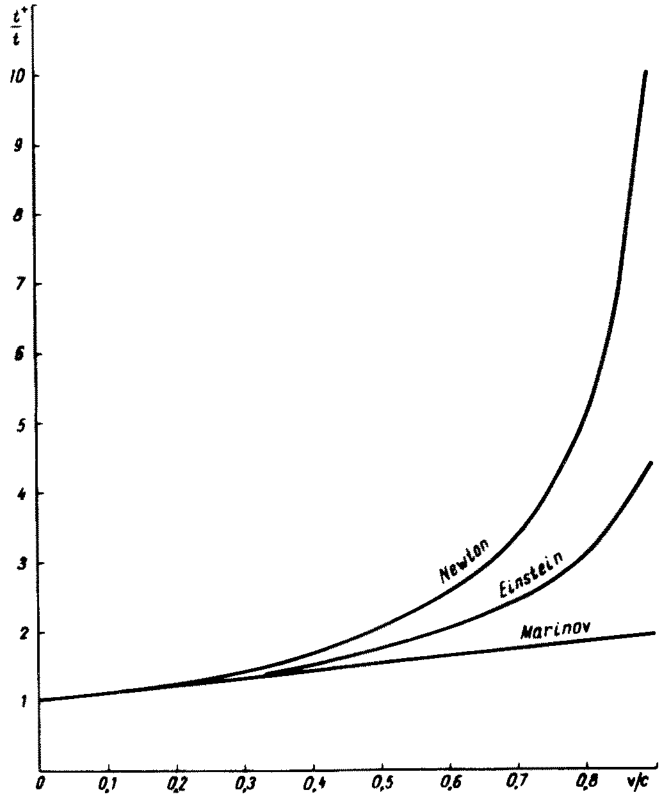

Fig. 3. The relative times in which the "direct" light pulse makes a whole revolution on the rotating disk, according to the theories of Newton, Einstein, and Marinov.

experiment (Marinov, 1976a), such a second-order experiment has to choose only between the Newtonian and our theories. Taking into account, however, that many second-order experiments (the Michelson–Morley experiment, the Ives–Stilwell experiment, and all experiments where the time dilation appears, i.e., the whole of high-velocity physics) have knocked out the traditional Newtonian ether theory, then the conclusion is to be drawn that at the present time only our absolute space-time theory corresponds to physical reality.

References

Burcev, P. (1974). *Physics Letters,* 47A, 365.
Landau, L. D., and Lifshitz, E. M. (1955). *The Classical Theory of Fields* (Pergamon Press, London).
Laue, M. von. (1955). *Die Relativitätstheorie* (Friedrich Vieweg & Sohn, Braunschweig).
Marinov, S. (1974a). *International Journal of Theoretical Physics,* 9, 139.

Marinov, S. (1974b). *Czechoslovak Journal of Physics*, **B24**, 965.
Marinov, S. (1975a). *Physics Letters*, **54A**, 19.
Marinov, S. (1975b). *International Journal of Theoretical Physics*, **13**, 189.
Marinov, S. (1976a). *International Journal of Theoretical Physics* (to be published).
Marinov, S. (1976b). *Foundations of Physics* (to be published).
Marinov, S. (1976c). *Journal de Physique*, (to be published).
Marinov, S. (1976d). *Foundations of Physics*, **6**, 571.
Shapiro, I. I. (1968). *Physical Review Letters*, **20**, 1265.
Tonnelat, M.-A. (1964). *Les vérifications expérimentales de la relativité générale* (Masson et Cie, Paris).