Transversal Fizeau Effect and the GRT

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The article analyses results of the transversal Fizeau experiment published in 2007 [1] from the point of view of the metric theory of gravity. This experiment is one of the first clear cut experimental proofs of invalidity of the Schwarzschild metric and the GRT. The results of this experiment have, of course, been conveniently ignored by the main stream relativistic physicists and theoreticians.

1. Introduction

In the 2007 paper [1] presented at the conference in Rochester NY, authors described the results of an ingenious transversal Fizeau experiment. This result clearly contradicts the special relativity theory (SRT) that is using the Fizeau effect as one of its cornerstone proofs of correctness. However, it is not the SRT that needs to be brought into question, it is the general relativity theory (GRT), since the experiments conducted on the rotating systems, which the transversal Fizeau experiment is carried on, experience an acceleration. This cannot be correctly described by the SRT that deals only with systems in an inertial motion. This paper offers the correct analysis of the transversal Fizeau experiment that is based on the previously developed metric theory of gravity instead of on the GRT or SRT.

2. Short Description of the Experiment

The photograph of the measurement setup for the transversal Fizeau experiment is show in Fig.1. This photograph was published by the SPIE newsroom and is available online.

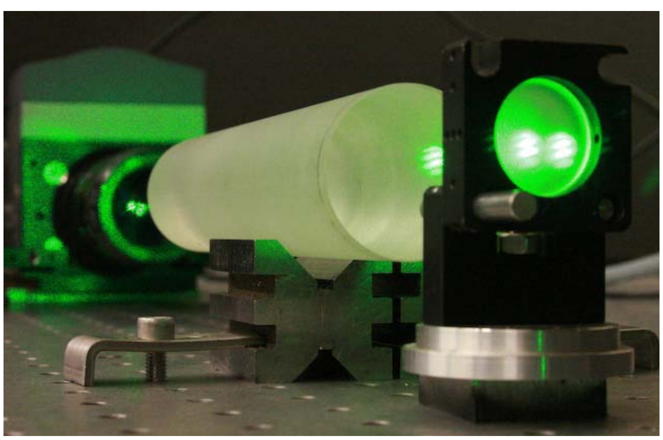

Fig. 1. The transversal Fizeau experiment setup where the light from a rotating light source is passing through the glass block. The image displacement due to the rotation is measured.

A rotating image is created by the interference effect and is projected on the translucent screen, so that a relatively high speed motion of the bright spot on the screen can be achieved without actually moving the light source. The moving bright spot is then observed through a glass cylinder or observed directly and the observed displacements are measured.

3. Analysis of the Experiment

The light passing through the optically transparent and moving medium is typically described by the SRT using the Fresnel dragging coefficient. The derived formula for this coefficient was among the first SRT predictions that was experimentally verifiable. This was accomplished by the famous Fizeau's experiment where the speed of light was measured in a moving water medium [2,3]. The light dragging coefficient is correctly derived for inertial systems using the standard relativistic addition of velocities of light and the moving medium as follows:

$$c' = \frac{c/n + v}{1 + v/cn} \approx \frac{c}{n} + v\left(1 - \frac{1}{n^2}\right), \tag{1}$$

where n is the index of refraction of the moving medium and v is its velocity relative to the stationary observer. The expression in parenthesis in Eq. (1) is thus the well known Fresnel light dragging coefficient.

However, in the author's previous publication [4] it was shown that in solid matter rotating systems the velocities add classically due to the presence of the centrifugal force. The derivation was based on the metric theory of gravity. The new metric that followed from the theory significantly differs from the GRT and the Schwarzschild metric. The metric was derived by assuming that the centrifugal force is balanced by the centripetal force of the solid platform material according to the formula:

$$\frac{\partial \phi_n'}{\partial r} m_0 \sqrt{1 - \omega^2 r^2 / c^2} = \frac{m_0 \omega^2 r}{\sqrt{1 - \omega^2 r^2 / c^2}}, \tag{2}$$

where for the inertial and the gravitational masses it was substituted the following:

$$m_i = \frac{m_o}{\sqrt{1 - v^2 / c^2}}, \tag{3}$$

$$m_g = m_o \sqrt{1 - v^2 / c^2}. \tag{4}$$

Solving Eq. (2) resulted in the gravitational-like potential whose gradient is the image of the centrifugal force and therefore simulates the centripetal force.

$$\phi_n' = \int_0^r \frac{\omega^2 r dr}{1 - \omega^2 r^2 / c^2} = -\frac{c^2}{2} \ln\left(1 - \frac{\omega^2 r^2}{c^2}\right). \tag{5}$$

The metric line element for the resulting curved space-time is then found by substituting this potential into the general metric line element formula for any axially symmetric space-time:

$$ds^2 = e^{2\phi_n'/c^2} c^2 dt^2 - dr^2 - r^2 e^{2\phi_n'/c^2} d\phi^2 - dz^2 . \qquad (6)$$

This finally leads to the metric line element that correctly describes the space-time of a rotating glass block, which is accounting for the effects of the centrifugal and centripetal forces:

$$ds^2 = \frac{c^2 dt^2}{1 - v^2/c^2} - dr^2 - \frac{r^2 d\phi^2}{1 - v^2/c^2} - dz^2 . \qquad (7)$$

From this metric line element it is then clear that the Lorentz circumference length contraction and the time dilation due to the rotation are precisely compensated by the metric coefficients of this metric. The rotating platform, therefore, appears Minkowski flat and as a result the light speed formula must be derived by simple addition of velocities:

$$c' = \frac{c - v}{n} + v = \frac{c}{n} + v\left(1 - \frac{1}{n}\right). \qquad (8)$$

The term in the parenthesis is thus the new and correct light dragging coefficient for the solid moving medium when the centrifugal forces are present.

The compelling evidence for the classical Galilean velocity addition on the rotating platforms comes from the measurements of the transversal Fizeau effect [1], where for the lateral image displacement Δ due to the source rotation as observed through a stationary glass block of a thickness L it was experimentally determined that it is: $\Delta = L(n-1)v/c$.

This formula is easily derived for the case of the rotating glass block and a stationary source using the new light dragging coefficient from Eq. (8). Considering that for the first order approximation for a relatively slow rotational velocities in comparison to c the photon travel time across the glass block thickness is still: $t_L = nL/c$, the lateral image displacement is equal to:

$$\Delta = t_L v\left(1 - \frac{1}{n}\right) = L\frac{v}{c}(n-1), \qquad (9)$$

An interesting aspect of this calculation is that this result agrees with the case when the light source is moving and the glass block is stationary thus having no centrifugal force in it. The advantages of such an experimental configuration are that the large velocities can be achieved and that the glass block is free of any rotation caused distortions and possible stress induced index of refraction changes. The image displacement due to the light traveling time in the glass block for this case is then:

$$\Delta = L\frac{v}{c}n - L\frac{v}{c} = L\frac{v}{c}(n-1). \qquad (10)$$

The term Lv/c represents the image shift when no glass block is present, which needs to be subtracted. The effect is thus perfectly symmetrical satisfying the source-observer relativity as expected and as is well known from SRT.

It thus seems that the image of the centrifugal force effect on the addition of velocities in rotating platforms is absolutely necessary in order to satisfy the basic tenet of relativity.

The experimental data confirming this result were presented at a conference in Rochester, New York in June 13, 2007 [1] and are shown in Fig.2. It is fascinating to see how well the experimental data agrees with this theory and how clearly it differs from the results predicted by the SRT. This can be considered as another proof that the developed metric theory of gravity and its application to rotating platforms is valid and corresponds to reality. Finally, this result thus clearly suggests that when Maxwell's equations are used to describe the EM fields and the wave propagation in solid rotating media, it is also necessary to account for the centrifugal forces and the resulting curved space-time metric.

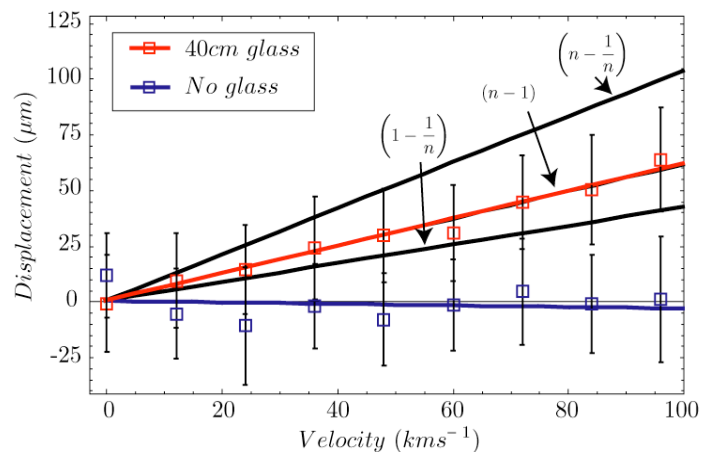

Fig. 2. The image displacement as function of the rotating image velocity. The data follows the classical formula rather than the relativistic formula for the light dragging coefficient. The graph was obtained from Ref [1] available online.

4. Conclusion

The new space-time metric that was previously used in resolving the Ehrenfest paradox is confirmed here again. The metric allows for a correct inclusion of the centripetal force into the considerations, which compensates for the time dilation and the length contraction effects of SRT. This is an interesting fact and a fundamentally very important finding that is contrary to the standard SRT point of view when analyzing the Fizeau experiments. The curved space-time effects caused by the image of the centrifugal force thus must be considered when evaluating the EM fields and the wave propagation using Maxwell's equations in rotating solid body platforms.

References

[1] M. Padgett, J. Leach, J. Götte, S. Franke-Arnold, L. Allen, A. Wright, “Moving images – are they laterally displaced by transmission through a stationary glass window?”, Conference on Coherence and Quantum Optics (CQO), Rochester, New York, June 13, 2007, Oral Session III, paper CME1.pdf (available online).

[2] A. A. Michelson, E. W. Morley, “Influence of Motion of the Medium on the Velocity of Light,” *American Journal of Science*, 3rd, **31** (185) (May 1886).

[3] M. H. Fizeau, "On the Effect of the Motion of a Body upon the Velocity with which it is traversed by Light", Phil. Mag. S. 4. Vol. 19. No. 127. April 1860.

[4] http://www.wbabin.net/Science-Journals/Essays/View/1498.