Transversal Fizeau Effect and the GRT

Jerry Hynecek

Abstract

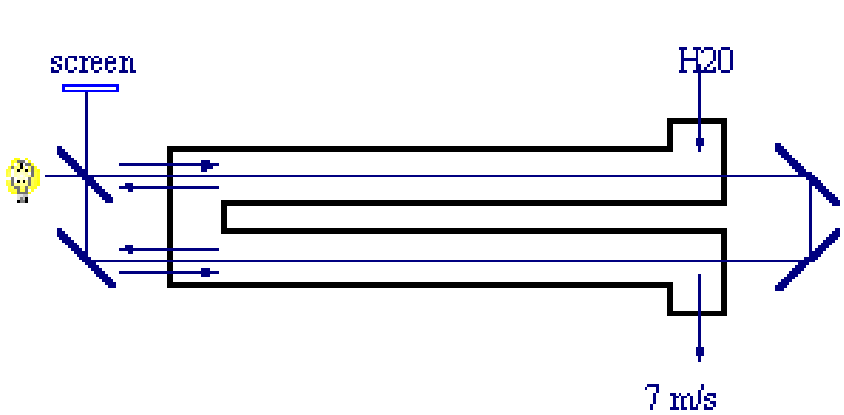
Why is the clock rate of clocks placed on the equator the same as the clock rate of clocks placed on the poles or placed anywhere else on the surface of Earth? The relative speed of an observer on Equator is 463 m/sec.

- This presentation explains in detail that when studying the effects of rotation on the motion of bodies or light, it is necessary to use the metric of a curved spacetime. Furthermore, it is shown that the relativistic addition of velocities in such systems is not valid and that the classical velocity addition must be used instead. It thus becomes clear that most of the Special Relativity Theory effects are nullified in such systems by the centripetal force of rotation and that the Special Relativity is thus strictly valid only in inertial systems. Finally it is confirmed that the inertial mass depends on velocity differently than the gravitational mass.

Outline of the presentation

- Description of the Experiment
- Effect of neglecting the centripetal force of Earth's rotation
- Metric Theory of Gravity
- Application to the Experiment
- Comparison with the Measurement
- Conclusions
- References

Description of the Experiment



- In the original Fizeau experiment the velocity of water was calculated from the volume of water that has passed through the apparatus at a given time.
- The relativistic velocity composition formula was used:

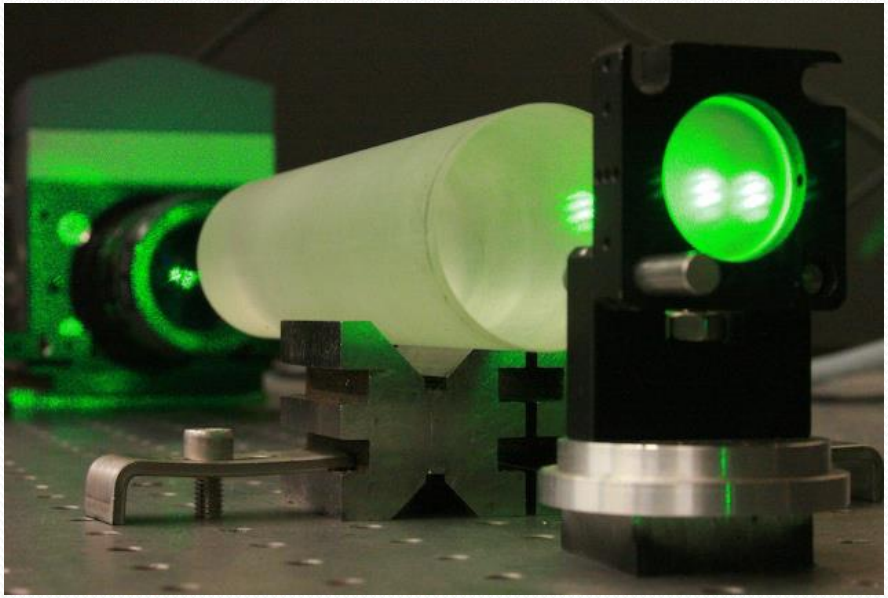
$$c' = \frac{c/n + v}{1 + v/cn} \approx \frac{c}{n} + v\left(1 - \frac{1}{n^2}\right)$$

- The description of the classical Fizeau experiment is as follows: the water flows against the beam of light in a tube. This causes an interference fringe shift on the viewing screen in comparison to the case when the water is not flowing.
- In the original experiment the water velocity profile across the tube was neglected, which led to a considerable error in the measurement.
- However, a more questionable assumption is the neglect of Earth's rotation and the corresponding centripetal force effect on the addition of velocities, the Fresnel dragging coefficient.
- The classical relativistic addition of velocities is valid only in inertial systems and this was used for the derivation of the Fresnel dragging coefficient.
- The transversal Fizeau effects is performed on solid platforms and thus seems more suitable for verification of SRT.

Problem of Neglecting the Effect of the Centripetal Force of Rotation

- In all the similar experiments such as in the Michelson-Morley interferometer test, Sagnac effect test, and the Fizeau experiment that were all conducted on the surface of Earth, the centripetal force of Earth's rotation was always neglected.
- This is a problem, since this force, even though much smaller than the gravitational force, has a significant effect on the validity and the applicability of SRT. The SRT, while still a correct theory, should not be used on systems that are not in an inertial motion.
- This is easily verifiable today by the GPS. It is a well known fact that the clock rate anywhere on the surface of Earth is the same. The clocks located at the same gravitational equipotential surface run with the same rate. However, SRT says that the clocks located at the equator should run solver in comparison to clocks located at the poles. This effect is not observed, so many people claim that the SRT is wrong.
- This discrepancy is some times called the Ehrenfest paradox and can be easily resolved by including the centripetal force of Earth's rotation into the considerations.
- This is the main contribution and the main point of this paper. It is not that the SRT is wrong, but it is applied where it should not be applied, which is in non-inertial systems.

Description of the Experiment



- The transversal Fizeau experiment setup where the light from a rotating light source is passing through the glass block. The image displacement due to rotation is measured.
- This photograph was published by the SPIE newsroom and is available online.

- Instead of measuring the light deflection when the glass cylinder is rotating, the glass cylinder was stationary and the light source was rotating.
- According to SRT the outcome of the test should be the same.
- The advantage of this arrangement is that large velocities of light source motion can be achieved and that there are no stresses in the glass cylinder that would affect the index of refraction.
- The details of this test setup, including the details of the interferometer that allowed the light source to circulate at high velocities, were published as referenced below:
- 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).

Metric Theory

- The light velocity in a transparent and moving medium is typically described by SRT using the velocity composition formula.

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

- The term is the parenthesis is the well known Fresnel light dragging coefficient.
- This formula was experimentally confirmed and is valid in the inertial systems where there is no acceleration.
- In the rotating systems, however we have a centrifugal force, which is an inertial force as a response to the centripetal force that is generated by the atoms of the glass cylinder that are being forced by the cylinder cohesion to move in circles with radial acceleration.
- The SRT, therefore, cannot be used to correctly analyze and describe this experiment.
- The correct description of the test is related to the Ehrenfest paradox, which states that according to SRT the circumference of a rotating disk should be contracted while the radius should remain the same. This implies a disk geometry that is not flat.
- There have been many paper published trying to resolve this paradox. Most of them using SRT. However, because SRT is valid only in inertial systems, this approach is bound to fail. It is necessary to use the GRT or other theories that describe the curved spacetime, such as the metric theory of gravity (MTG). The MTG approach is the approach that will be used here.
- The general differential metric line element that describes the axially symmetric curved spacetime can be written as follows:

$$ds^2 = e^{2\varphi'_n/c^2}(cdt)^2 - dr^2 - r^2 e^{2\varphi'_n/c^2} d\varphi^2 - dz^2$$

where the rotational axis is the z-axis and where φ'_n is the gravitational-like pseudo-potential.

- From the point of view of the disc atoms it should not matter whether they are forced to orbit in circles by the disk cohesion forces or by the gravitational-like force acting directly on the atoms themselves.

Metric Theory

- The gravitational-like force and its pseudo-potential thus precisely simulate the centripetal force.
- The pseudo-potential is calculated from the force equilibrium condition as follows:

$$\frac{\partial \varphi'_n}{\partial r} m_0 \sqrt{1-\omega^2 r^2/c^2} = \frac{m_0 \omega^2 r}{\sqrt{1-\omega^2 r^2/c^2}}$$

Here it was assumed that the inertial mass and the gravitational mass depends on velocity according to the formulas:

$$m_i = \frac{m_o}{\sqrt{1-v^2/c^2}} \qquad m_g = m_o\sqrt{1-v^2/c^2}$$

By integrating the force equilibrium condition the formula for the pseudo-potential is found:

$$\varphi'_n = \int_0^r \frac{\omega^2 r dr}{1-\omega^2 r^2/c^2} = -\frac{c^2}{2}\ln\left(1-\frac{\omega^2 r^2}{c^2}\right)$$

- It is now only necessary to substitute this result into the general metric line element formula and obtain the metric for the spinning disc that correctly accounts for the centripetal force:

$$ds^2 = \frac{(cdt)^2}{(1-v^2/c^2)} - dr^2 - \frac{r^2 d\varphi^2}{(1-v^2/c^2)} - dz^2$$

- This is an interesting result that clearly shows that the Lorentz length contraction factor is precisely compensated by the curved spacetime metric coefficient in the circumference direction and as a result the disk circumference will not appear to be contracted.
- This is a very important finding, which the main stream science does not consider for example in the analysis of the Sagnac effect or in the Michelson-Morley experiment. The rotating disk has a Minkowski-flat spacetime geometry.
- The implication for the transversal Fizeau experiment is that the velocity of light in the transversal direction of a rotating cylinder adds classically by a simple Galilean velocity addition:

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

Measurement Results

- The light dragging coefficient in the transversal direction when the centripetal force is present is therefore:

$$\left(1-\frac{1}{n}\right) \qquad \text{instead of:} \qquad \left(1-\frac{1}{n^2}\right)$$

- This is an important distinction that follows directly from the resolution of the Ehrenfest paradox using the MTG instead of the GRT.
- The GRT with its Schwarzschild metric and the identical dependencies of inertial and gravitational masses on velocity contradict this finding.
- From the MTG and the flat spacetime geometry of a rotating disk, when applied to Earth also follows that the clock rate anywhere on the surface of Earth should run with the same rate. This has been confirmed by the GPS as already mentioned.
- Once the light dragging coefficient is known it is simple to calculate the image shift. It is only necessary to know the cylinder rotation velocity at the radius where the light beam is propagating and the time the light spends in the cylinder:

$$t_L = nL/c$$

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

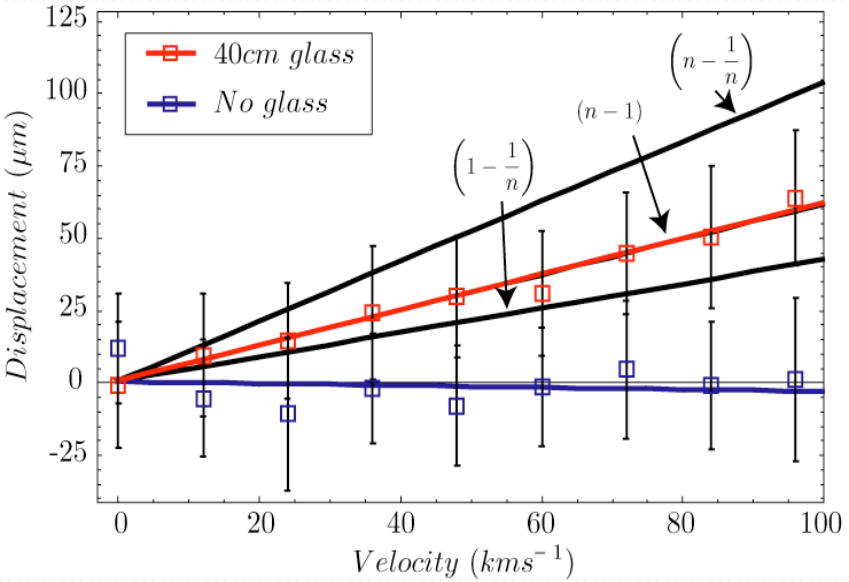
- For the case of the stationary cylinder and the rotating light source, it is possible to think of the cylinder as a delay line. The light source will shift by the delta that is proportional to time the light spends in the cylinder times the source rotational speed. The time the light spends to travel the distance without glass must, of course, be subtracted.

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

Measurement Results

- This is exactly what is observed as shown below.

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



- It is fascinating to see how well the measurement agrees with the theory. The image shift closely follows the classical speed composition formula rather than the relativistic speed composition formula.
- The important observation to take away from this experiment is that the basic tenet of relativity, the relativity between the source and the observer, is satisfied. The formula for the rotating source and the stationary cylinder is the same as the formula for the rotating cylinder and the stationary source.
- The relativity of the source and the cylinder would not be maintained without considering the curved spacetime metric and the different dependencies of inertial and gravitational masses on velocity.
- The agreement of the measurement with the formulas obtained from the theory thus confirms the assumptions.

Conclusions

- The following far reaching consequences can be drawn from this experiment.
  - The relativity of the source-observer motion as postulated in SRT is maintained.
  - The GRT with its Schwarzschild metric does not describe the reality correctly. It cannot be used to resolve the Ehrenfest paradox and thus correctly describe this experiment.
  - The inertial mass and the gravitational mass depend on velocity differently. The Einstein's weak mass equivalence principle (WEP), therefore, does not hold for moving masses, it holds true only when there is no relative motion.
  - The famous equation: $E=mc^2$ is, therefore, valid only for the inertial masses and not for the gravitational masses in motion.
  - The important consequence of the here verified gravitational mass dependence on velocity is that the light does not have gravitational mass, it has only inertial mass. This also implies that the Black Holes with their event horizons do not exist. There are only very compact massive objects from which light and matter can always escape. The evidence for this claim is the observation of the well-known galaxy central mass jets.
  - It is not correct to describe the system with acceleration by a sequence of infinitesimal Lorentz coordinate transformations. The centripetal force cannot be ignored.
  - Finally, when studying the EM fields and propagation of light in moving solid transparent media where the centripetal forces are present it is necessary to consider curved spacetimes.

References

- More complete descriptions of the Earth's centripetal force effect on the resolution of the Ehrenfest paradox, MM experiment, and the Sagnac effect can be found on the web using the links shown below.
- I have not seen the effect of Earth's rotation on these experiments studied anywhere else, so my apologies for the lack of other references.

- http://physicsessays.org/doi/pdf/10.4006/0836-1398-25.2.256
- http://gsjournal.net/Science-Journals/Research%20Papers-Relativity%20Theory/Download/1497
- J. Hynecek, "Experiment to Internally Measure the Earth's Rotating Speed and the Calculation Comparison with the Relativistic Treatment", Applied Physics Research, Vol.4, No.3, August 2012.

Thank you for the attention